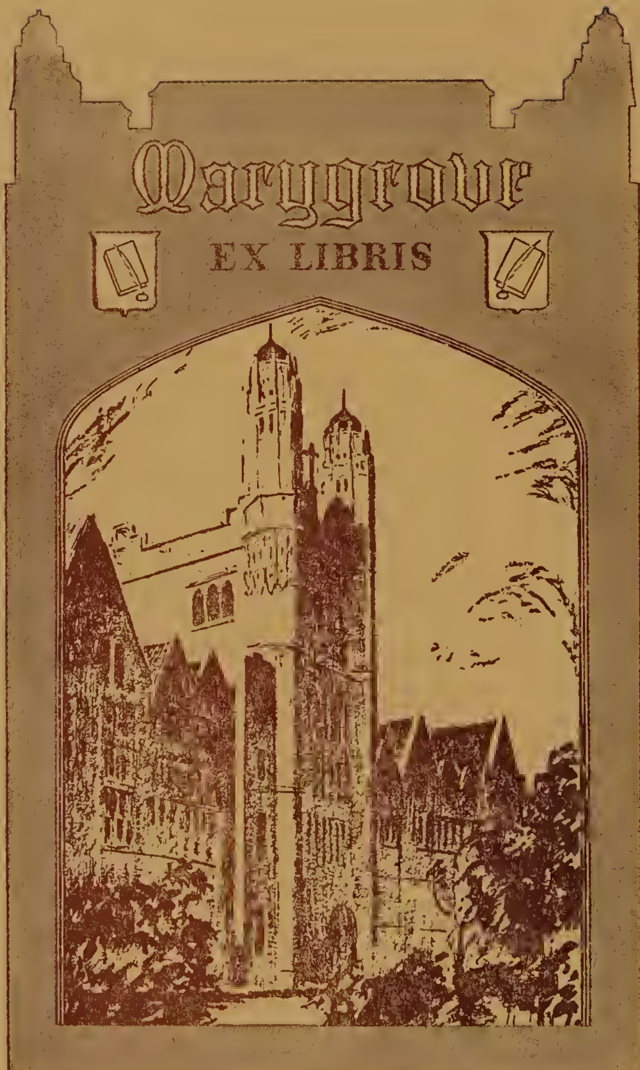
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American Ship Types

American Ship Types

A Review
Of the Work, Characteristics, and Construction of Ship Types peculiar to the waters of the North American Continent

BY

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American Ship Types is most interesting in its portrayal of past and present conditions in domestic American shipping, and I feel sure that it will be helpful in the effort to develop an American Merchant Marine.

The pages of the book contain a thorough analysis of the domestic shipping enterprises of the United States. The work is a valuable addition to our limited literature on this subject.

T. V. O'Connor,
Chairman, U. S. Shipping Board.

Contents

INTRODUCTION

IT IS not generally realized that the northern portion of the American continent, and in particular the United States, has an important mercantile marine which is entirely domestic, and which, from the time of the Revolution almost, has developed characteristics differing so materially from local or domestic shipping in any other part of the world that it has been judged necessary to compile a book which sets out specifically to discuss, to classify, and to clarify these characteristics. It is a trite axiom that the prophet is only without honor in his own country; but this without question is due to no fault on the part of the prophet, neither can blame be laid directly at the door of his countrymen. Their fault is an unconscious one, and because the prophet is always with them they are unaware of his presence, importance, or value. So also is the fleet of mercantile vessels which I have labelled American Ship Types. The average citizen who lives in a seaport town is so accustomed to his double-ended ferries, the New Yorker who lives on Staten Island considers the wonderful tug fleet as part of the everyday landscape, while the inhabitant of St. Louis, Cairo, or Memphis is so entirely familiar with his churning stern wheel towboats, packets, and barges that the fact of their possessing any special characteristics seldom enters his head. This applies, too, to very many people professionally interested in shipping, though perhaps to a less extent. But even so, owing to the vastness of the country, domestic shipping tends rather to confine itself within watertight divisions, and the East Coast operator will not bother much about the operating conditions of ships on the West Coast, while neither is particularly concerned with the troubles of Western River Navigation. Similarly the Great Lakes may seem to be almost in another world to the operator of a catamaran ferryboat on, say, the lower Mississippi. Each district has been fitted out differently by Nature

and has imposed therefore its own special conditions on the naval architect. Also, though now perhaps to a small extent, the influence may be traced in the development of domestic ship type characteristics in various districts of the early colonizing nations. Hudson River barges, for example, are vaguely reminiscent of the modern barges which work inland from ports like Rotterdam, and we may perhaps assess a measure of the Dutch stolidity to their bluff lines.

The consulting naval architect is, perhaps, the most ready to realize the definiteness of characteristics that the American domestic ship presents; but even here, the tendency is toward specialization, and one man devotes his energy mainly to ferry boats, while his neighbor makes a name as a designer of day passenger vessels, and so on.

The object of this book, then, is to present the whole matter in perspective, showing the number of domestic ship types, their principal characteristics, and the interrelation of one type with another, this latter being largely a question of geography. All ship types are, of course, the victims of geography; in fact, it is marine geography, or the configuration and relationship of the land and water masses of the world to one another which has created the ship. The American domestic ship is especially affected by geographical conditions as will be seen. Before proceeding, therefore, to a detailed character study it is obviously necessary to take a rapid glance at the configuration of the American seaboards, at the location and physical formations of the principal rivers, and of the Great Lakes. This will show how bays, sounds, creeks, rivers and lakes and the necessity for the transport of peoples and merchandise from port to port along their length has given rise to the necessity for different classes of ships which go to make up the American domestic mercantile marine. Then, having once analysed this, we can see how characteristics of nature have imposed conditions, in most cases limiting, of construction upon the various ship types.

As I have mentioned already, much of the information exists already in scattered form; some in dusty pigeon holes in office

desks, much more, perhaps, in the form of practical experience in shipping men's minds. Hence, I have called the work a cohesive work, because in it I have endeavored to gather a useful and comprehensive set of facts regarding a very vital factor in American progress and development. The work cannot pretend to be absolutely complete. It covers a very wide field; from the Great Lakes to the Gulf, from New York to San Francisco. This much it does carry out, however. It collects characteristics, comments on them, foreshadows developments, and presents each type as part of a homogeneous whole.

The Diesel engine is rapidly revolutionizing domestic shipping as it is also revolutionizing ocean shipping and in many of the types considered an attempt is made to point out the advantages which this type of prime mover has over the steam engine, as well as its limitations.

A. C. Hardy

New York, N. Y.
January, 1927

Outline Geographical Survey

Shows Over 28,000 Miles of Coastline with Varying Characteristics

THIS book is a shipping book and not a geographical treatise. It is necessary, however, to deal briefly with the coastwise geography of the United States before considering the effect which this has upon the characteristics of the many and varied ship types common to domestic waters. The country may conveniently be divided into definite physical regions. The low Atlantic plain is separated by the Appalachian mountain system, rising to a height of about 6700 ft., from the great central plain extending north and south from the Gulf of Mexico to the Great Lakes System. This district is of the greatest commercial and economic importance; it contains the rich and fertile Middle West region and is the valley through which flow the Mississippi, Missouri, and Ohio rivers. Then comes a region which is part of the great Cordilleran Plateau system, a system occupying the west of the North American continent from the Isthmus of Tehuantepec — to the Arctic. This comprises the Rocky Mountains rising to a height of 14,370 ft. in Mt. Harvard; the Great Basin having an area of 228,000 square miles, which includes in the center of the plateau the Great Salt Lake of 4200 square miles area and has no outlet to the sea, and the Sierra Nevada range on the Pacific coast rising to a height of 15,000 ft. in Mount Whitney. Finally there is the Pacific Coastal region, mountainous and fertile. The vast region so briefly dismissed above contains very naturally tremendous contrasts of climate and vegetation and these contrasts apply also to the coast lines, with which we are especially concerned here.

For the most part the eastern seaboard is indented by bays, sounds, and rivers while the west coast and more particularly the north west has indentations and inlets, rising sheer from the sea, which are rocky and extremely difficult to navigate; but, whereas the eastern seaboard is rocky in the Maine district, flat and sandy from Long Island south to Georgia, and of coral formation to Key West, the west coast is high and rocky throughout, and well timbered in the north western section. As an illustration of this, remember that on the whole of the Pacific coast there are only four lighthouses which exceed 100 ft. in height; in fact, the Farralon light tower, 23 miles distant from the Golden Gate, the entrance to San Francisco Bay, although it has a focal height of 358 ft., is only 41 ft. high. The lighthouse on the low, sandy Cape Hatteras on the Atlantic side is built up practically from sea level to a height of 193 ft. It is estimated that the North American continent has a coast line development of 28,130 miles, or one mile of coast line to every 33.4 miles of area.

For purposes of studying the domestic shipping of the United States, we can divide the "water" portion into the following sections — arbitrary, but natural and convenient. Thus, the Atlantic Seaboard may be considered as extending from the Canadian border to Key West: the Gulf Coast extends from Key West to the Mexican border (i.e., the Rio Grande): the Panama Canal Zone is a separate item: the Pacific Coast extends from the Mexican-Californian border to Alaska including British Columbia and Alaska: the Great Lakes form a special section which can be treated in conjunction with the St. Lawrence estuary, while finally come the great rivers of the central plain.

The Eastern Seaboard

It is just 160 miles from Portland, Me., the most northerly port of first-class importance on the eastern United States seaboard to the lighthouse on West Quoddy Head, the first lighthouse after the Canadian border and the easternmost point of the United States. The Maine coast, which is nearly 200 miles in length, is both intricate and rocky. There are numerous islands off the

coast line and these, in conjunction with the climatic conditions including the presence of fog and ice, render navigation neither safe nor easy. This, however, is largely offset by the excellence of the coast lighting, there being no less than 1266 navigational aids on the outer coasts and inland waters, or an average of over six to the mile of general coast.[1] Portsmouth with its Navy Yard, Gloucester and Salem, homes of the Grand Banks fishing fleets and Boston are all important points on the New England coast

The Maine Coast is both intricate and rocky.

line. Boston is situated at the apex of a triangular shaped bay at the two base angles of which are Cape Ann and Minot's Ledge respectively; Salem and Gloucester being situated on the leg of the triangle running in a north easterly direction. There is a dangerous collection of ledges and rocks lying north east of the entrance known as The Graves and marked by a powerful light. Minot's Ledge at the southern apex of the triangle marks reefs extending two miles from Cohasset Harbor. It is one of the best known and most dangerous light stations in the whole of the

[1] See "Lighthouses and Lightships of the United States," by George R. Putnam. New York. The Houghton Mifflin Co. 1917.

United States. Quincy, close to Boston, has the Fore River plant of the Bethlehem Shipbuilding Corp., Ltd., one of the largest ship construction organizations in the country. Hook-shaped Cape Cod Peninsula is now separated from the mainland by the Cape Cod Canal, opened in 1914, which forms a valuable short cut for coastwise traffic from New York via Long Island Sound. This canal has a length of 13 miles and a depth of 25 ft. The waters to the south of Cape Cod are treacherous and difficult to navigate and no less than six lightships mark the passage through Nantucket Sound to Buzzards Bay at the apex of which the Cape Cod Canal is situated. Much fog is experienced in these waters at some seasons of the year and at one of the lightships [1] 386 hours of fog were registered in one month. During one year a total of 17,496 vessels passed this same lightship. Most of these were engaged in coastwise traffic.

Coastwise, the next large indentation is Narragansett Bay with Providence at its head, soon after which is Long Island which straddles the Connecticut shore. The island itself is low and sandy and contains no harbors of any commercial importance; its Atlantic coast forming the north shore, as it were, of the outer approaches to New York Harbor. The low, picturesque Connecticut coast has the ports of Bridgeport, New Haven and New London, the latter with a large Diesel construction plant, and Long Island Sound, the inner channel to New York, is the scene of tremendous coastwise activity. Ambrose Channel, main outside channel to New York Harbor, is a dredged passage through the shoals having a width of 2000 ft. and a depth of 40 ft. The commencement of this passage is marked by the Ambrose Channel Light Vessel which is always taken by transatlantic vessels as the beginning or end of their run. New York Harbor is in many ways one of the ideal harbors of the world, but those very characteristics which make it so wonderful bring in their train difficulties of transport which have been responsible for the development of many of the ship types discussed in this work.

[1] Pollock Rip L. V. See "Lighthouses and Lightships of the U. S.," previously referred to.

The Eastern Seaboard is indented by bays, and sounds, and has ship types which may be identified by comparing the index numbers with those on the plate.

Car floats, derricks, transfer tugs, stake boats, ferryboats and others all owe their *raison d'être* to the fact that New York grew on Manhattan island, expanding perforce upwards and later spreading over on to the Long Island and New Jersey shores. The Hudson River, the city's proximity to Long Island Sound via the East River and other similar factors have all combined to make New York the center of a vast amount of domestic shipping. Via the Hudson River and the State Barge Canal, it is in direct water communication with the Great Lakes. It is the wheel hub from which radiate spokes to New England ports, to Boston, to the St. Lawrence and to the ports of Georgia, the Carolinas, and the Gulf Coast, while the opening of the Panama Canal has made the journey by water to the west coast an easy matter, where formerly it was a pilgrimage.

The New Jersey coast, running south to Cape May, is flat and sandy and contains no important ports. Below it come two of the largest sound systems on the American coast lines, the Delaware River and Bay, and the Chesapeake Bay with the wide estuaries of the James, York, Rappahannock, Potomac, Patuxent, Susquehanna, Chester, Choptank, Nanticoke, and Pocomoke Rivers emptying into it. Delaware Bay contains the important ports of Philadelphia and Wilmington while the Chesapeake Bay system includes Baltimore, Annapolis with its Naval Academy, Washington, Norfolk, Hampton Roads, and Newport News, the latter an important shipbuilding center, while the last three are among the largest coaling ports in the world. The Delaware and Chesapeake Bays are linked at the neck of the Delaware peninsula by a canal which was opened in 1829 and has a length of 29.63 miles and a depth of 10 ft. To all except shallow draft barges and towboats it is relatively useless. In the winter months Delaware Bay is frequently blocked by ice and ice movement is dangerous not only to shipping but also to some of the screw pile lighthouses with which shoals in certain parts of the bay are marked. In the center of Delaware Bay stands Fourteen Foot Bank lighthouse, one of the best known lighthouses in the world, built up on a submerged steel concrete-filled caisson. This was

placed in position in somewhat the same manner as the caisson upon which stands the Roter Sand lighthouse at the entrance to the Weser River in Northern Germany. The coast from the Delaware to Chesapeake Bay is much encumbered by sandbanks and there are five lightships stationed off shore at distances up to 16 miles along this stretch. As is usual on coast lines of this type, a certain amount of erosion goes on. At Cape Charles, for example, at the Chesapeake entrance the coast line has been wearing away gradually, while at Fishing Point, Md., at the entrance to Chincoteague Inlet, further north, a long tongue of land is gradually building itself out. Both the Chesapeake and the Delaware are the scenes of vast domestic shipping activity and in some cases (for example, between Baltimore and Norfolk, Va.) water transportation of passengers is quicker and more convenient than railroad transportation. The railroad running down the Delaware Peninsula is connected with Norfolk and Newport News by means of a system of tugs and car transfer barges, and there is also a packet passenger service between these points.

South of Chesapeake Bay the coast continues low and there are extensive inland navigable waters including the Albermarle and Pamlico Sounds which, with rivers and channels, form a nearly continuous inside route for yachts and small craft from the Chesapeake to Florida. Cape Hatteras is at the apex of a triangle formed by the low sandy coastal spits which protect Albemarle and Pamlico Sounds from the Atlantic Ocean. It is on this cape that one of the most important landfall lights on the eastern seaboard is located. Extending 8 miles to seaward from this point are the well known and treacherous Diamond Shoals, the seaward end being marked by a light vessel bearing their name. This vessel is moored in 30 fathoms of water about 13 miles eastward of Hatteras. So severe is the weather at times that the light vessel itself has been driven ashore near the cape. Ships bound up coast from Carribbean or Florida ports make a landfall at Diamond Shoal Light, and vessels laden with bananas for New York or Boston sometimes stop in fine weather and take over a bunch of bananas to the light vessel's crew, a custom which com-

bines courtesy with publicity — when there are passengers on board.

Between Hatteras and Charleston there are three nearly equidistant capes, each with dangerous shoals in its vicinity — Capes Lookout, Fear and Romain. The port of Wilmington (North Carolina) is on Cape Fear River, 30 miles above its mouth. The dangerous Frying Pan Shoal extends more than 7 miles southwards from Cape Fear. The Georgia and Florida coast lines are low, swampy, and sub-tropical in parts. In this region Savannah and Jacksonville, both of which are well served by coastwise steamship lines, are the principal ports of commercial importance. Miami is a port which has increased in importance considerably during recent years as a result of real estate activity. At the lower end of Florida there are low coral reefs having a convex curvature with respect to the Florida Channel and terminating in Key West. The Florida Channel is an extremely crowded waterway with its north and south bound coastwise traffic, traffic from Europe crossing from the Bahamas, and ships coming up from the Caribbean direct and via Havana. Lighting of the reefs is taken care of here in a very efficient manner by tall screw pile lighthouses erected on coral formations.

The Gulf Coast

The coast line from Key West to the Rio Grande has a length of about 1629 miles, being generally low and sandy. The coral formation extends from Key West to Apalachee Bay. From Mississippi Sound to Galveston Bay, there are offshore shoals which are liable to change with severe storms. The bottom is mainly sand and silt, and from Galveston to the Rio Grande there is a fairly regular sandy bottom which is free from off lying dangers. In about latitude 27 deg. N.[1] where the trend of the coast changes from south west to south east, a counter current is formed which, attaining considerable velocity of rotation is sometimes called the Whirlpool of the Gulf. The most important

[1] See also United States Coast Pilot. Gulf Coast — Key West to the Rio Grande.

ports and harbors on this stretch of coast are Mobile at the head of the bay of that name, Gulfport, New Orleans, and Galveston with Texas City and Houston situated in Galveston Bay.

New Orleans is on the Mississippi River 81 miles above the Head of the Passes. It is an important cotton and grain port and is also the terminal for carriage of freight up the Mississippi River. Head of the Passes is the point at which the Mississippi delta branches into four toe-like extensions, as the Gulf Coast Pilot describes them, consisting of narrow banked deposits of sand and clay brought down by the river current. The waterways between these banks are the passes or entrances to the river proper, and they are named respectively, Pass à l'outre, North East Pass and South East Pass (these are virtually one), South Pass, and South West Pass. The bays between the Passes are slowly being filled by wave and tidal action from the Gulf of Mexico and by sedimentation from river overflow from above. The Mississippi mouth and its surrounding waterways are intricate but well buoyed and marked, and they are the home of a considerable amount of domestic traffic as will be seen later.

Behind New Orleans is Lake Pontchartrain, a stretch of fresh water 792 sq. miles in area and 10 to 16 ft. deep, forming at its eastern end with Lake Borgne a connecting link, some 8 ft. deep, for inside navigation between Pontchartrain, the Mississippi River, and Mississippi Sound. Mississippi River is also direct connected with Lake Borgne by the Lake Borgne Canal. Pontchartrain is linked at its western end by Pass Manchac with Lake Maurepas, about 10 ft. deep, important as an approach to the Tickfaw and Amite Rivers, both of which have considerable local trade with New Orleans. There is a considerable amount of traffic in small power boats on Lake Pontchartrain with New Orleans.

From New Orleans to Sabine Pass there is a network of shallow inland waterways "lying within the region of alluvial deposit by the Mississippi River and consisting of vast stretches of marsh . . . and many lakes from one-fourth of a mile to 30 miles in length. These inland waters are intersected by navigable waterways called bayous having a general north and south direction . . . The depth

of water in the bayous is nearly always sufficient for navigation by river craft and not infrequently is as great as 20 to 30 ft. for miles in succession. The lakes are generally shallow . . . There is a large traffic on these waterways in fish, oysters, logs, lumber, rice, sugar cane, fertilizers, vegetables, and general merchandise. The intercoastal waterway forms a connecting link between these bayous and affords an outlet for their products to the markets in New Orleans and other cities." [1]

"Depth of water in bayous is sufficient for navigation by river craft."

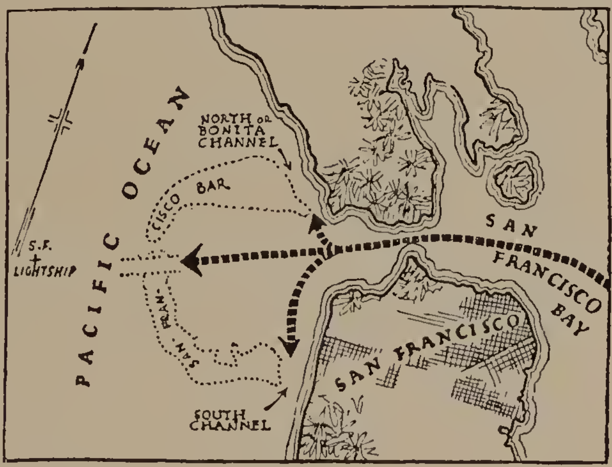
Galveston is situated at the eastern end of a long, narrow island which partly straddles the shallow Galveston Bay. It is an important port, having a considerable domestic as well as foreign trade. The terminal facilities are the most extensive on the Texas Coast. Galveston Bay is the approach to East and West Bays, Houston Ship Channel, Texas City, and Houston, as well as to numerous towns and bayous. The Bay and its tributaries form one of the most important ports commercially in the United States, having an extensive foreign and coastwise trade in crude petroleum, and its refined products, cotton and cottonseed products, wool, grain, rice, fruits, ore, and lumber products.

[1] See Gulf Coast Pilot. Pp. 153, 168.

The Pacific Coast

The Pacific Coast is precipitous and rocky, and presents quite different problems in navigation from the Eastern and the Gulf Coasts. There is much coastwise traffic, but of a somewhat different nature to that found on the other coasts, as will be seen. The southernmost port is San Diego, Cal., important as a naval base, from which port the coastline curves in a north westerly direction to Point Conception, marking one end of the Santa Barbara Channel, named for the Santa Barbara Islands situated off the coast at this point. Los Angeles, with its port San Pedro, second port of the state, which exports much California produce, is approached from the south by the San Pedro Channel. Los Angeles and San Diego have frequent and excellent coastwise passenger and freight express service with San Francisco, and Los Angeles has a service direct to Hawaii.

Terminal port for Far East and Australian trade, for passenger and freight connections to the Hawaiian Islands, and for coastwise services, San Francisco ranks easily as one of the leading seaports of the United States. The port itself is just inside the entrance to the Bay — nearly 40 miles long and from 3 to 12 miles wide and having no less than 40 ports along its shore — named for the city, connecting with San Pablo and Suisun Bays as well as the mouth of the Sacramento and San Joaquin Rivers. The Golden Gate, passage between the Pacific Ocean and San Francisco Bay, has an average width of slightly less than $1\frac{1}{2}$ miles and a depth of water which increases from 23 fathoms at the western end to over 60 fathoms at the

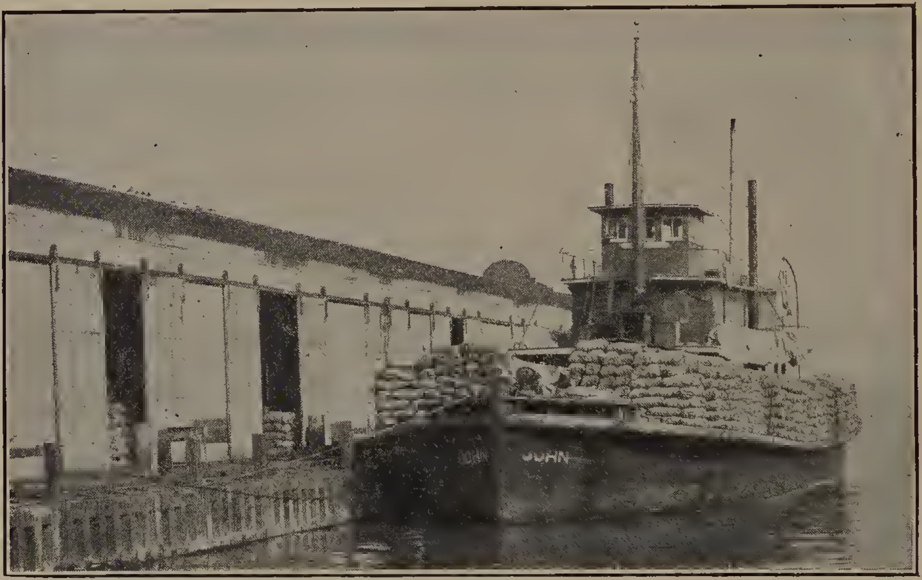


S. F Chronicle

The Golden Gate — San Francisco's door to the world.

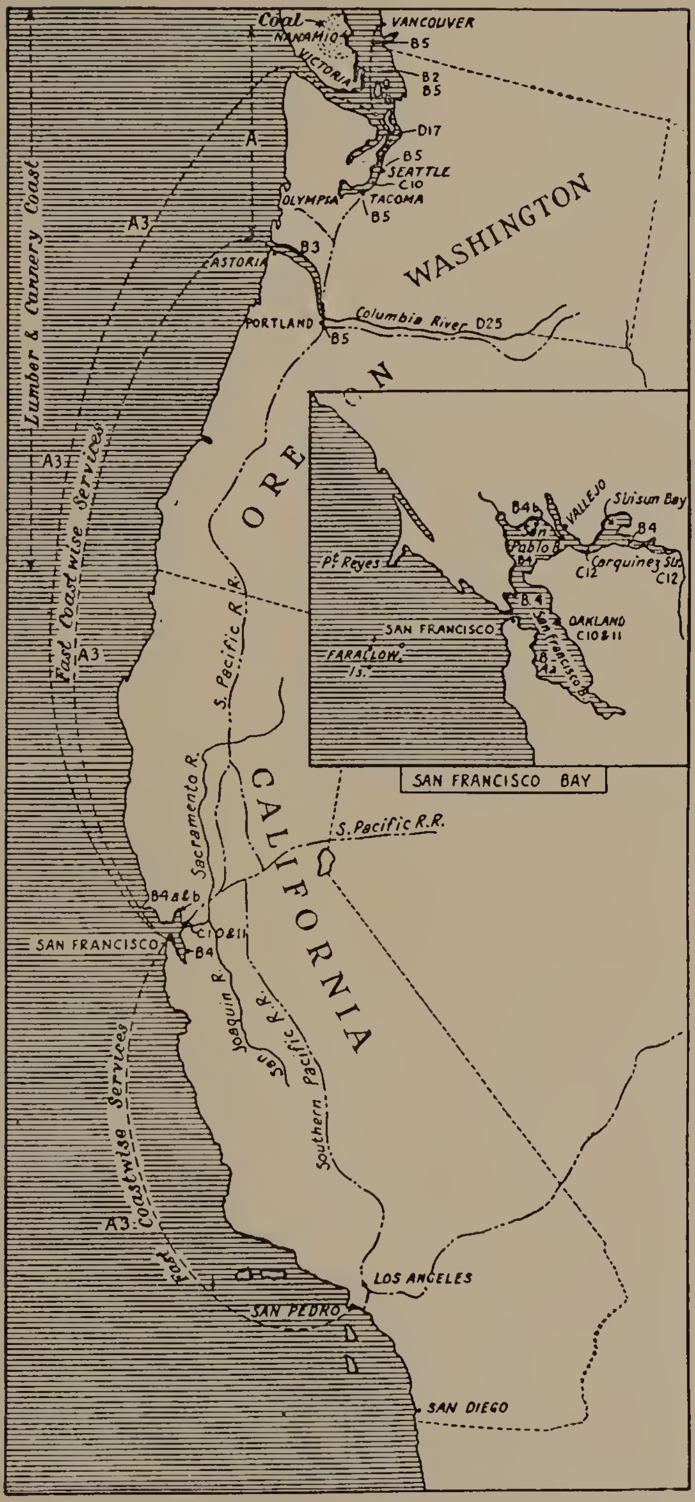
eastern end. San Francisco Bay with its attached bays and rivers forms the largest natural harbor and anchorage on the United States coast line. The Bay proper extends nearly 40 miles southward from its junction with San Pablo Bay. Opposite San Francisco is the second largest city in the bay — Oakland, and between these two places there is an important ferry service which will be discussed later.

San Pablo Bay is about 10 miles long and 8 miles wide and has a large area of shoal water and mud flats. It communicates with Suisun Bay at its eastern end by means of Carquinez Strait, a



Light draft vessels of this and similar types go up into Suisun Bay.

funnel shaped connection 6 miles long, less than ½ mile in width for the first 3½ miles length, and expanding later to a width of about 1 mile. An important railroad "cut-off" is made across this strait by means of a special type of car ferry. Suisun Bay is really the delta of the Sacramento and San Joaquin Rivers, and is largely marshy and shallow. There is considerable traffic on San Pablo Bay, heavy draft vessels passing across to load grain at Carquinez Strait ports and also to load flour and discharge lumber at South Vallejo. Light draft vessels go up into Suisun Bay and up the Sacramento and San Joaquin Rivers. The San



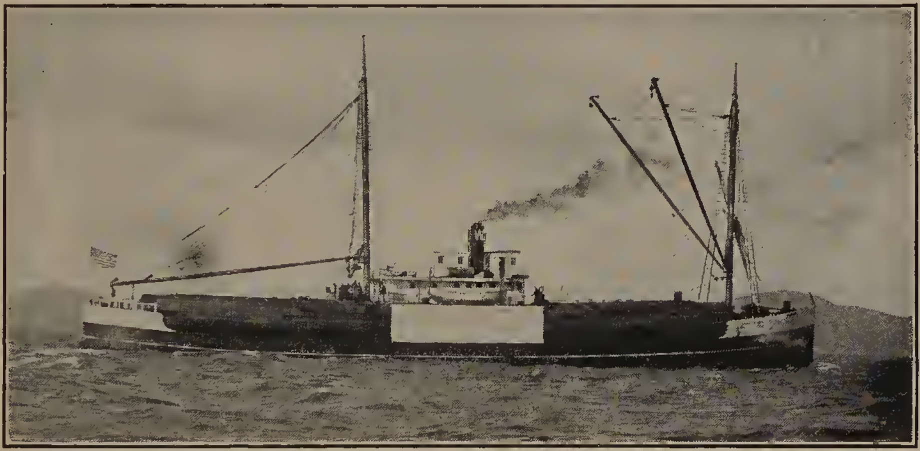
Ship type index numbers for the precipitous and rocky Pacific coast make interesting comparison with the Atlantic seaboard.

Joaquin and Sacramento deltas are both extremely fertile and are now well cultivated, producing such crops and vegetables as potatoes, asparagus, onions, barley, corn, etc. The highways of communication are waterways and they are sheltered and deep. The rise and fall of the tide is slight. The district depends for its food and communication upon shallow draft work-boats and sternwheelers, and in some ways is comparable with parts of Georgia and Louisiana. San Francisco Bay with its attached bays forms quite a distinct domestic waterway "section" and the local traffic is heavy. Much of the freight handled on the bay is carried in shallow draft river steamers, barges, and flat bottomed scow schooners.

Between San Francisco Bay and the Columbia River the coast-line, though generally rugged, is somewhat more variable than that south of San Francisco, and the high ground is well timbered, particularly in the Columbia River region. At "landings" on parts of this coast, lumber farm and dairy produce is shipped in small coastwise vessels to San Francisco, loading and unloading being carried out by means of wire cables. Some of these small coastal "landings" have no railroad communication. Throughout its length, the Oregon coast is pierced by small river entrances, such as the Coquille, Siuslaw, and Yaquina Rivers, from all of which there is coastwise trade in lumber, canned fish and dairy produce. Communication to some points is of an irregular nature.

Columbia River and its tributaries are navigable by ocean going steamers to Portland on the Willamette River and Vancouver 98 and 92 miles respectively above the mouth and by light draft vessels as far as Lewiston, Idaho, 406 miles above the mouth. Trade, both foreign and domestic, is considerable and there are numerous lumber, mining, and cannery stations situated along the banks of the Columbia and its tributaries served by shallow draft ships of varied design and capacities. Exports from the district are principally lumber, grain, fruit, and fish, while imports comprise fuel oil, coal, cement, manufactured goods and general merchandise. The natural abundance of good pine makes the

building of the wooden fore and aft auxiliary schooners, for which this part of the Pacific Coast is well known, a local industry. The entrance to Columbia River, once difficult to navigate, has been improved by the construction of north and south jetties and by dredging. This has led to the construction of large special type dredges which, as will be seen, are among the finest and most powerful in the world. The depth over the bar at low water is now generally in excess of 30 feet.



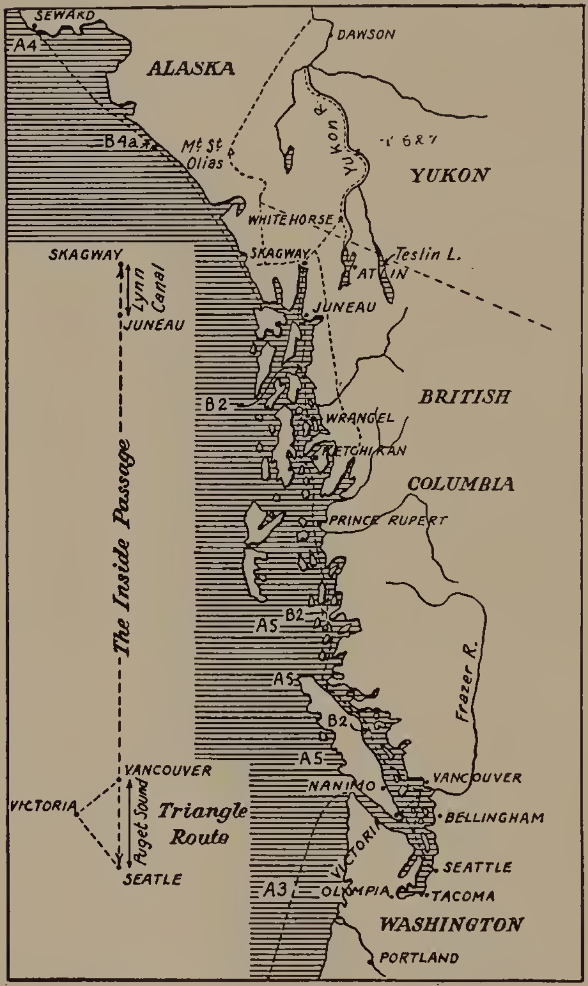
Lumber is exported from many points on the Pacific northwest coast.

North of Columbia River the coast is low and sandy with heavily wooded hinterland. Lumber is exported from points on the coast, such as Grays Harbor, a conical shaped bay which is an outlet to a large timber growing area. The bay contains two or three small towns and two rivers flow into it.

Juan de Fuca and Tributaries

Comparable with San Francisco Bay as a partly enclosed water section, the body of water with which Juan de Fuca Strait forms the connecting link to the Pacific Ocean extends southward to Puget Sound and northward to the inland waters of British Columbia and Alaska. It contains the important ports of Vancouver, Seattle, Olympia, Victoria and Tacoma and is the center of an extensive domestic shipping activity with ship types having

characteristics differing from those of vessels found elsewhere in North American waterways, including "coasters" of British type, Puget Sound "box car" freighters, car floats, fast passenger and mail ships resembling the British cross-channel type, and ferries.



The inland waters of British Columbia and Alaska are centers of extensive domestic shipping activity.

Lumber, fish, grain, coal and general merchandise are exported, while there are also several important manufactures.

The general arrangement of this waterway section is perhaps best appreciated by considering Juan de Fuca as part of an inclined stock to a letter "T," the bar to the "T" being formed by Puget Sound and its northward extensions. Juan de Fuca[1] separates Vancouver Island from the state of Washington and extends approximately 50 miles eastward to Race Rocks, with an average width of over 10 miles. Eastward of Race Rocks it runs east and north east for 20 miles, with an average width of over 18 miles, connecting northward with Georgian Strait through the channels of Washington Sound and southward through Admiralty Inlet which enters in its south eastern part with Puget Sound. The shores are heavily wooded and rise rapidly to elevations of considerable height.

[1] See also U. S. Coast Pilot. Pacific Coast.

Puget Sound[1] extends about 53 miles in a southerly direction and then south west for about 30 miles, expanding into numerous inlets and passages, the majority of which are navigable by deep draft vessels. Few deep draft vessels, however, pass south of Tacoma, communication with points beyond being maintained with small Puget Sound craft from Seattle or Tacoma. Olympia, capital of the state of Washington, is on Budd Inlet, the southernmost inlet of Puget Sound. Tacoma, second largest city on the Sound, exports flour, cotton, wheat, machinery, and lumber and is important in the Alaskan trade. Largest city on the Sound, Seattle has ocean communication with all parts of the world. It has excellent railroad facilities and is the center of a large sound and coastwise (e.g., to San Francisco) trade as well as for transportation to Alaska via the Inside Passage. Coal, lumber, grain, fish and machinery are the chief exports. Everett and Bellingham, both ports with about 30,000 inhabitants, are exporters of lumber, paper, flour, canned fish, logs and dairy products. Bellingham has a special automobile ferry service from Sydney, on Vancouver Island, maintained by the Canadian Pacific Railway.

Vancouver Harbor, B. C.,[2] on the east shore of Georgia Strait on the British Columbia mainland, is entered from English Bay by a channel known as the First Narrows, a passage less than $\frac{1}{4}$ mile wide and about 5 miles long, where heavy traffic combined with currents exceeding 8 knots makes navigation difficult in the fogs that occur at some seasons. False Creek runs in from English Bay immediately to the southward of the city and along the entire southern part of the west portion of the city. Here on reclaimed land are the terminals and yards of the Canadian Northern and Northern Pacific Railways. Vancouver is the center of much industrial activity. It exports lumber, has a considerable lumber business and is a large grain center. There are 12 different steamship lines which maintain domestic passenger, passenger-cargo, and cargo services to Vancouver Island, Puget Sound and

[1] See also U. S. Coast Pilot. Pacific Coast.

[2] See also "Canadian Port and Harbor Directory."

United States Coastal ports. The Canadian Pacific Railway Company maintains a triangle service with fast special ships with passenger and baggage accommodations between Vancouver, Seattle, and Victoria, which latter port is at the south eastern end of Vancouver Island and at the eastern end of Juan de Fuca Strait. Lumber, coal, cereal foods, marine paints, and biscuits are among the principal exports. Coal is also exported from Nanaimo on the east side of Vancouver Island, which has a three track car ferry

Canadian Pacific Railway maintains passenger services in picturesque B. C. waters.

slip, making connection with the main line of the Esquimault and Nanaimo Railroad. Cars are transported to the mainland of British Columbia from the slip by means of special car floats, and the service is comparable to that maintained between Cape Charles and Norfolk, Va.

The Alaskan Coast

The Alaskan coastline [1] has a length measured in 30-mile steps of 7300 miles as compared with a total of 4884 miles for the Atlantic, Pacific and Gulf Coasts. The coast generally is rocky, precipitous and intricate to navigate and the hinterland is sparsely settled. A great deal of rain and fog is experienced and there are very strong currents. Much of the coast is ice-free only for a short time each year and is not visited much by ships. The

[1] See "Lighthouses and Lightships of the United States" previously referred to.

south eastern coast is well fringed with islands and coastwise navigation goes by way of the well-known Inside Passage from Seattle to Skagway, 975 miles in length, which early navigators took for an actual passage between Atlantic and Pacific. Dawson is on the Yukon River about 335 miles north of Skagway and

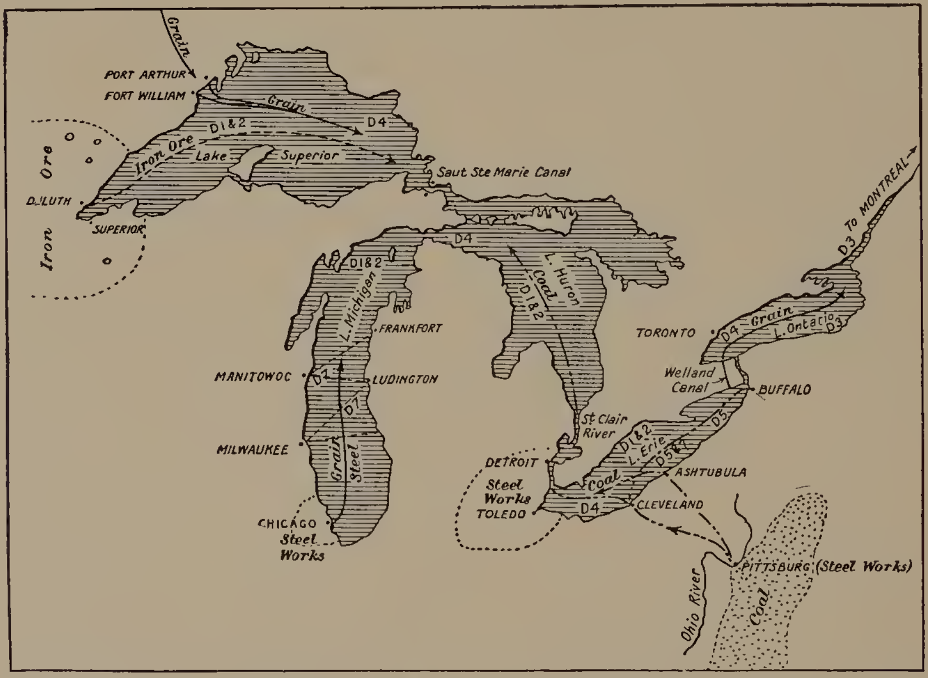
Standard Oil Co. reaches customers in farthest Alaska by modern electric tankers.

freight is carried during the few months of the year in which the Yukon River is open to navigation, i.e., June to September, by fast shallow draft steamers from White Horse to Dawson and by rail from Skagway. Vessels make the journey downstream from Whitehorse. Navigation on the Yukon is carried up as far as Fairbanks, over 10,000 miles from the river mouth. The inside route to Skagway from Seattle is exceedingly well taken care of as far as navigation marks are concerned and it has, in 375 miles of Alaskan waters, 62 lights, including 9 float lights and gas buoys and 7 fog signals. Off Yakutat Bay and Cape St. Elias, there are extensive halibut fishing grounds.

Great Lakes and Inland Waterways

Are Centers of Vast Activity in Bulk Cargo Transportation

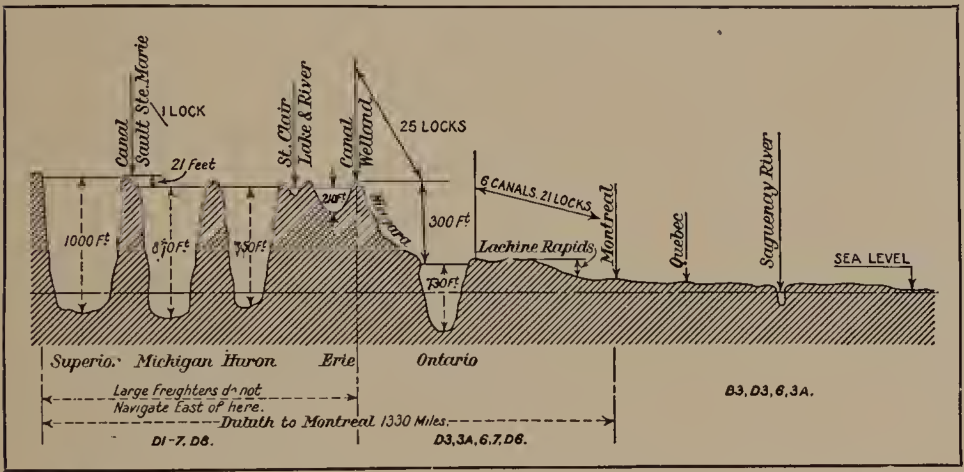
THE Great Lakes System represents from the point of view of shipping one of the wonders of the world. It comprises six inland fresh water seas, having a total estimated area of about 95,000 square miles, surrounded by some of the richest industrial and agricultural areas of the North American continent. Of these



The Great Lakes, operating many ship types, have a total area of 95,000 sq. miles.

six lakes, Lake Superior is the largest and deepest, having an area of 32,000 square miles and a maximum depth of about 1000 ft. Lake Huron comes next from the point of view of area with 23,000

square miles but its maximum depth is only 750 ft. as compared with 870 ft. of Lake Michigan with 22,000 square miles area. Lake Erie has an area of 10,000 square miles and a maximum recorded depth of about 210 ft. The comparative shallowness makes it subject to violent storms, while Lake St. Clair, really a connecting link between Huron and Erie, has a maximum depth of only slightly over 22 ft. with an area of 400 square miles. Lake Ontario, easternmost of the group has an area of 7200 square miles and a maximum depth of 730 ft. The lakes are not at the same



Imaginary section through the Great Lakes provides some interesting contrasts.

height above sea level. This has necessitated the construction of a series of locks and canals in order to render through navigation possible from points on one lake to points on another. Lake Superior, as well as the deepest is also the highest above sea level and there is a drop of some 21 ft. over the falls of Ste. Marie to Lakes Huron and Michigan which, connected by the Mackinac Strait are each 581 ft. above sea level. Lake St. Clair, the St. Clair and Detroit Rivers connect Lakes Huron and Erie. There is a drop of over 300 ft. between Lakes Erie and Ontario over the Niagara Falls and River and this is taken care of as far as merchant shipping is concerned by the Welland Canal[1] with 25 locks. The St. Lawrence River is the natural outlet for the Great Lakes System to the sea and here again there is a gradual drop

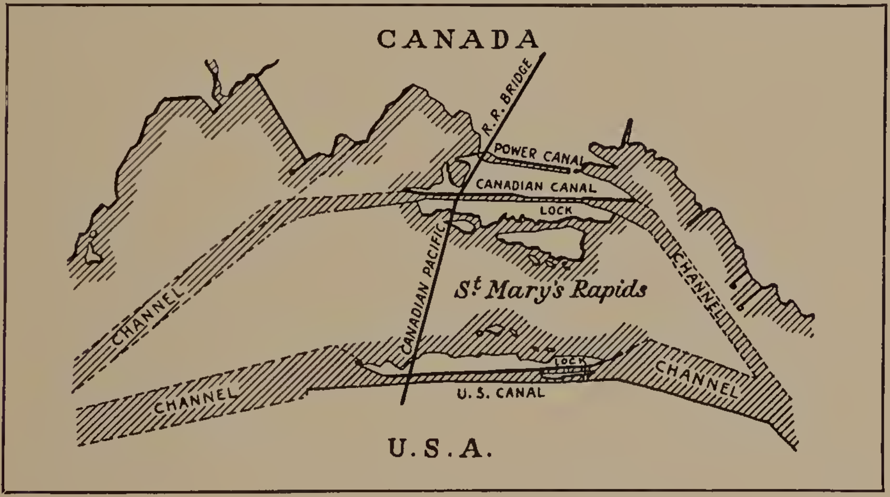
[1] See also Chapter XI of the author's "Bulk Cargoes" (Van Nostrand Inc.).

to sea level, the route being partly canalized (6 canals and 21 locks) between Lake Ontario and Montreal. The New York State Barge Canal System is the artificial outlet for traffic from the Great Lakes. This waterway comprises the Erie Canal from Tonawanda on the Niagara River to Waterford on the Hudson River (339 miles); the Oswego Canal from Oswego on Lake Ontario to Three Rivers on the Erie Canal (24 miles); the Cayuga-Seneca Canal including the lakes of those names (92 miles), and the Champlain Canal (60 miles). The total mileage including harbors is 525 and connection is made with the Hudson River at Waterford. Distances on the lakes are greater than would be imagined from a casual glance at the map. From Duluth, the ore port at the western end of the lakes, to Montreal — (i.e., the complete length of the system plus the canalized portion of the St. Lawrence River) is a distance of 1339 miles. From Buffalo the largest eastern port to Duluth is 1115 miles.

Bulk cargoes such as grain, ore, and coal figure very largely in Great Lakes shipments, partly owing to the natural resources of the surrounding districts and partly because the lakes form a cheap channel of transportation between the East and the West and vice versa for bulk commodities such as those mentioned above. For these cargoes there is a continual supply and demand, and therefore in the majority of cases they be transported more cheaply by water than by rail. In Minnesota, for example, round about Duluth on Lake Superior, there are deposits of readily obtainable iron ore. In West Virginia are immense deposits of coking coal, and Pittsburg is one of the greatest steel and iron making centers in the United States. Minnesota sends its iron ore from Duluth and Superior, via the Sault Ste. Marie Canal, to the blast furnaces of Detroit, center of the automobile industry, on the St. Clair River, to Toledo, to Cleveland, Ashtabula, Conneaut, and Buffalo on Lake Erie partly for transshipment to the Pittsburg district, and partly for domestic use, and to the Chicago district. In return West Virginia sends coal to Duluth and Chicago, for domestic use via the lake ports Cleveland and Ashtabula, or to be carried further west by railroad. Chicago, at the toe of Lake Michigan, sends the

grain to Buffalo, via the Mackinac Straits for distribution in the East and for export to Europe. Grain cargoes reach the Eastern ports either in railroad freight cars, or in barges via the New York State Barge Canal System or in small freighters if Montreal is the port of shipment. Chicago also exports steel products in ships of a special type — not differing vastly from the ordinary canal type — to Montreal for re-export to all parts of the world. Calcite, Rockport, and Alpena, Mich., export stone in large quantities — limestone for use as flux in blast furnaces and crushed stone for building, road making, and breakwater construction.

Canada concentrates the grain of Alberta at Fort William and



Sault Ste. Marie — world's wonder canal — handles more traffic in 8 months than Suez and Panama together in 12 months.

Port Arthur and sends it via Superior, Huron, and Erie either to Port Colborne at the entrance to the Welland Canal or straight through to Montreal where it is stored before transshipment or shipped direct to ever-hungry Europe via the St. Lawrence River and Estuary. Transportation of these cargoes forms the main activity of the lakes; there is a certain amount of local package cargo work between port and port as well as coastwise and there is also a flourishing tourist industry such as, for example, between Buffalo and Duluth with intermediate calls, in American ships, and between Port McNicoll, on Georgian Bay a branch of Lake

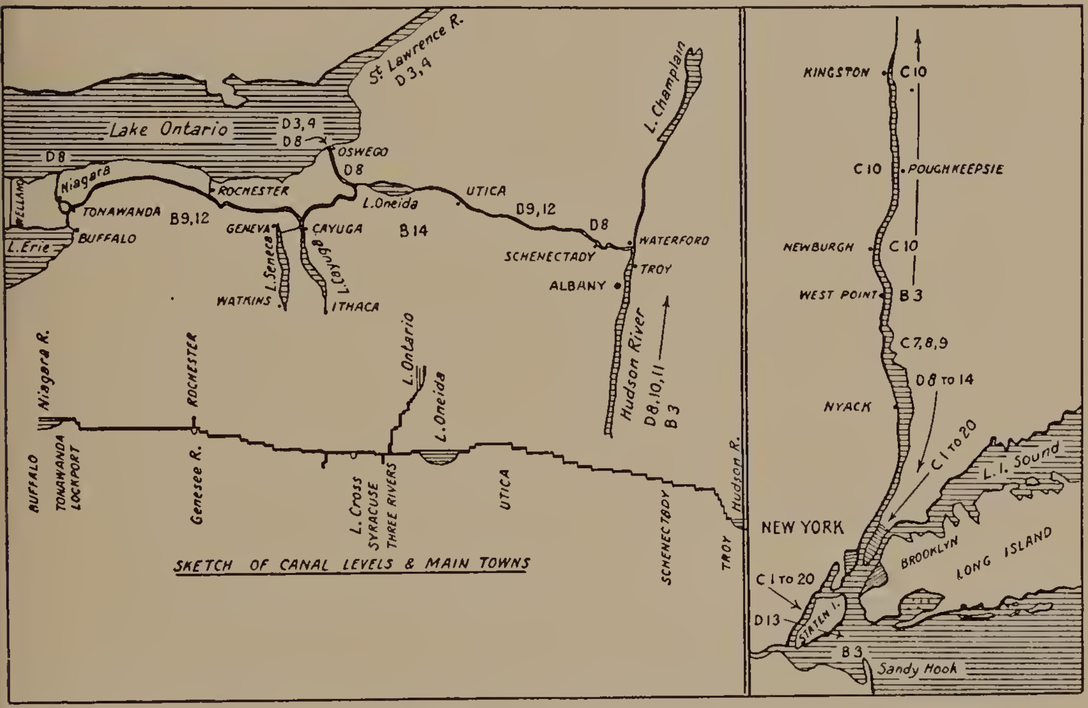
Huron, and Fort William in Canadian ships. There are also express passenger services, such as between Cleveland and Buffalo on Lake Erie, maintained by some of the largest and fastest side wheelers in the world.

When it is reflected that navigation is only possible between the months of May (late in the month) and December owing to ice, it will be realized that during the open months intense shipping activity prevails and quick dispatch is the keynote of operation which in turn has had a far reaching effect upon the design not only of Lake ships but also of their terminals. Lake ports handle ships more quickly than any other ports in the world. They have to. The Sault Ste. Marie passes through it in its active months as much tonnage as the whole of the rest of the ship canals of the world put together. The Welland Canal, almost as busy, links the Great Lakes with Lake Ontario and thus with the St. Lawrence Estuary and River and European ports. Welland Canal limits the size of vessels passing east of Lake Erie and has an important effect upon design as will be seen later. Certain routes on Lake Michigan have an all year round train ferry service, the ferries themselves being of ice breaker type. There is, for example, the Milwaukee, Wis. – Ludington, Mich. route of the Pere Marquette Railroad and the Manitowoc–Frankfort route of the Ann Arbor Railroad. Similar routes exist on Lake Ontario.

New York State Barge Canal

This has been mentioned already as the artificial outlet from the Great Lakes to the Atlantic Ocean via the Hudson River. It is furthermore the only all-American water connection. The waterway itself although possessing certain limitations regarding height for vessels passing under its bridges is capable of taking the size of ship which uses the Welland Canal and the St. Lawrence Estuary. It is handling an appreciable and an increasing amount of traffic but the freight carried is largely of bulk cargo type and the canal is not used to anything like its full capacity. To a great extent the same conditions apply with regard to railroad compe-

tition as are met with in the case of the Western Rivers. Railroads at the present time suffer from congestion and this is especially so at the New York railroad terminals owing to their "willy nilly" situation with respect to Manhattan Island. It is sometimes quicker on this account to transport merchandise from Chicago or Duluth to New York by water than by rail owing to



New York State Barge Canal, artificial outlet from the Lakes to the Hudson River and the Atlantic, is the home of towboats and barges.

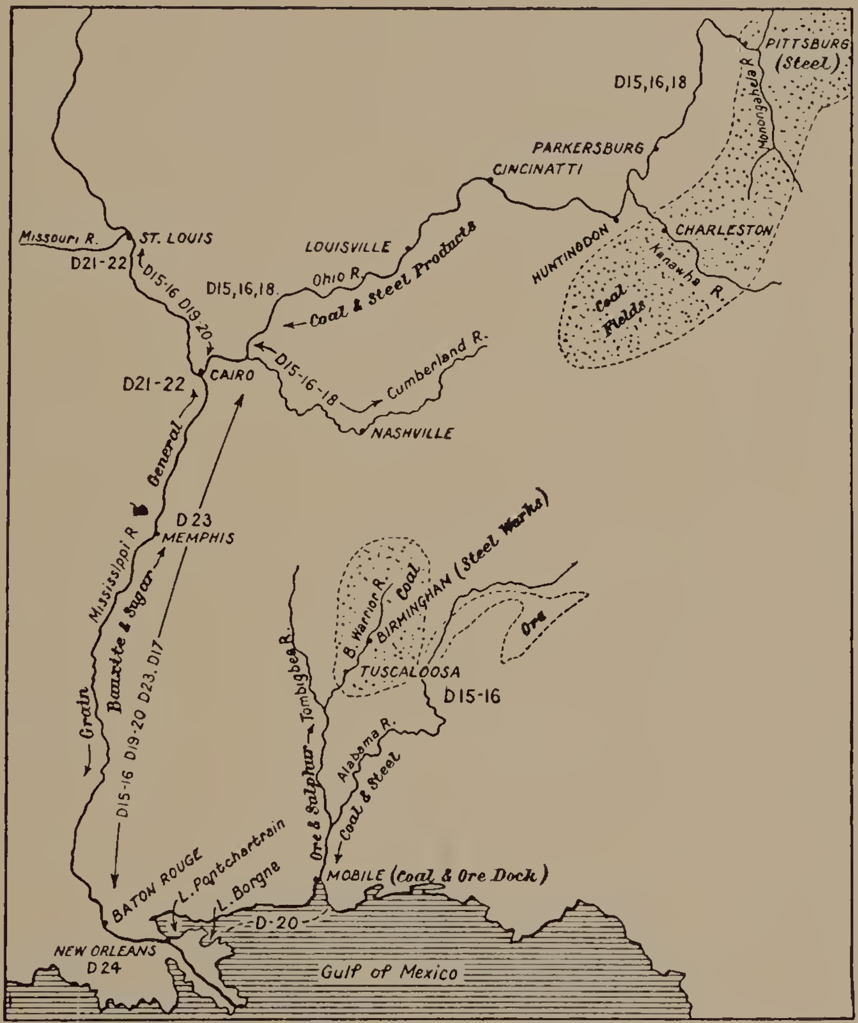
terminal congestion at the New York end. Furthermore the Diesel engine is now providing an economical means of transport both in tugs and in canal freighters and many firms are realizing this and equipping themselves with their own barge lines operated by motor tugs. These latter can bring freight right up alongside the ocean-going steamer at her pier and obviate any delay through transshipment. It is folly to suppose that the railroads can ever be supplanted, but the waterways can prove a very useful auxiliary. Modern towboats and barges designed upon modern scientific principles must be used to take full advantage of the barge canal.

The Canal is owned by the State of New York and is operated and maintained solely at its expense. Navigation is free, no charge being made at the locks. The canal system links Lakes Erie, Ontario, and Champlain with the Atlantic Ocean via the Hudson. The available length inside lock chambers is 300 feet and the minimum clearance under fixed bridges is $15\frac{1}{2}$ feet.

The Rivers

These, as far as any definite navigation is concerned, comprise the Ohio River from Pittsburg to Cairo with its tributaries the Kanawha, Monongahela, and Cumberland Rivers; the Mississippi from St. Louis to its mouth, and the Alabama, Tombigbee and Black Warrior Rivers together with their connections with the Mississippi via the Lake Borgne Canal and Lake Pontchartrain. (See Chap. 1.) The above form one composite group with their own trade and ship types. They are sometimes known collectively as The Western Rivers. Columbia River with its tributaries form another group. From the navigator's point of view they are not ideal streams by any means; from the designer's point of view their characteristics force him to try to cram the proverbial quart—of strength and power—into the pint pot—of shallow draft, with not always the best of results. A policy on the part of Congress of keeping a reasonable depth of water at all seasons of the year by means of canalization and locks is rapidly placing Western River navigation on a proper footing. In the early days of expansion and colonization of the West and the Middle West the Ohio and Mississippi rivers formed one of the principal trade and transportation arteries between the east and the south west and west. River craft of the day attained a high state of development and efficiency. Then came the railroads, bitterly opposed at first, but later expanding to such an extent that Western River traffic fell away practically to nothing. Furthermore, the decrease in traffic has produced no incentive, except in certain cases, towards improvement in design or general arrangement of ships operating on the Western Rivers, with the

result that many of these are substantially the same as those which were in commission fifty and sixty years ago. The Inland Waterways Corporation, a government concern, has done much to improve Western River navigation and also the design of Western



The Western Rivers, home of the pushboat, and the barge, are carriers of bulk freight, capable of 100 per cent development.

River ships. It has barge lines at present in operation which can compete with the railroads very successfully from the point of view of cost of transport. Much of the cargoes carried on these waterways, as on the Great Lakes, is of a bulk nature. This is

for two reasons, firstly because bulk cargoes are always of such a nature that there is a continuous supply and demand for them and hence speed of transit is not a primary consideration. Secondly bulk cargoes are located within easy reach of the Western Rivers. The West Virginia coal fields are near the Ohio, Kanawha, and Monongahela Rivers. There are ore mines in Alabama within reach of the Black Warrior, Tombigbee and Alabama Rivers and the transport lines controlled by the Inland Waterways Corporation provide cheap and reliable transit for freight upon these waterways, in many cases far cheaper than the railroad can carry freight over a similar distance.

Considerable controversy has arisen over the relationship between railroad and modernized inland waterway transportation. It does not come within the scope of this book to discuss the ethics of this. Some points, however, are at once patent in this connection: The railroads on many routes are so burdened with freight that a state of saturation occurs, giving rise to some remarkable anomalies, as Brig. Gen. T. Q. Ashburn, Chairman of the Inland Waterways Corporation, pointed out in a series of articles contributed to the *Chicago News*.

A large manufacturing concern of Alabama, — he says — which uses a certain kind of ore in its manufactures, and owns its own mines of this ore in the State of Alabama, can get this same ore from Sweden, transport it by sea to Mobile, thence by the Warrior Barge line to Tuscaloosa, Ala., and deliver it at its plant cheaper than it can produce its own ore at its own mines, and transport it by rail to its manufactory.

The Aluminum Ore Co., located at East St. Louis, and owning its own bauxite mines in Arizona, can, he further states, operate its own ships from its own mines in the Guianas of South America, and utilizing the Mississippi service from New Orleans to St. Louis (paying the barge line $3 per ton for its transportation), can do it more cheaply than it can deliver at St. Louis bauxite from its Arizona mines.

As offsetting the disadvantage of the Alabama firm in its competition with Swedish products, it is interesting to note that this

same aluminum company of East St. Louis turns part of its bauxite, received as above described, into concentrates, ships the same to Sweden by barge line and ocean steamer, and sells it in Sweden cheaper than Sweden can produce the same concentrates; all on account of cheap water transportation.

In such cases it seems folly not to take advantage of the waterways to help matters out. This in turn points to the fact that any services by water should be part of a chain of transport. Waterway systems and the craft operating on them can never exist by themselves as they did in the old days before the railroads arrived. It is true that certain bulk cargoes can be unloaded at, say Mobile and taken up to Birmingport and unloaded there without touching a railroad system. This, however, does not apply to all cargoes. Even where it does, the railroad does not suffer, as Brig. Gen. T. Q. Ashburn, Chairman, points out in "Waterways and Inland Seaports."[1] In citing the case of Pittsburg he says:

"The establishment of the steel industry drew workers, naturally who wanted the necessities, the comforts, and the luxuries of life. As the industry expanded, more raw material had to be collected, more finished products distributed, more workers and their families came, each of these causes contributing to an ever increasing demand for transportation. This cycle expanded continuously, until to-day the Monongahela River is carrying annually 26,000,000 of tons, and the Pennsylvania Railroad, instead of being hurt, has four times expanded its Monongahela division, which is practically given over to freight handling. What the river took away from the railroads in its handling of bulk commodities, it returned fourfold to the railroads in the creation of demands for supplies and distribution that could not be handled by the river alone."

This is true, of course, not only of American Waterways but of the great European Waterways[2] which link Rotterdam and Antwerp with the interior of Europe. In this case the traffic is largely

[1] Washington: Government Printing Office. Price 10 cents.

[2] See the author's "Bulk Cargoes" (Van Nostrand Co.).

of bulk nature, ore inwards to the interior and coal outwards from the Ruhr Basin in Germany and yet one does not find the European railroads shutting up shop.

Europe, however, has the advantage of waterways of a more reliable nature than are the Western Rivers in this country. Here operators have to put up with shifting courses, lack of water which places appalling limitations upon design, and heavy weather

Western River Traffic is being revolutionized by modern craft of this and similar types.

conditions. Canalization and dredging can largely eliminate the first two difficulties and careful attention to strength and comfort in design can help the latter. The Western Rivers are essentially the traffic lanes for bulk cargoes which do not require speedy transport but for which there is always a steady demand. It is convenient to consider the Western Rivers in three sections: The Ohio River with its tributaries Kanawha, Monongahela, and Cumberland Rivers, the Mississippi from St. Louis to New Or-

leans, and the Alabama, Tombigbee, and Black Warrior Rivers with their part-coastwise, part-canal, and part-lake connection with New Orleans. The Ohio and its tributaries from Pittsburg to Cairo at the junction with the Mississippi carry much of the outward coal freight from the West Virginia coal fields as well as finished products from the Pittsburg steel works. The development of this traffic has led to the introduction of several distinctive ship types as will be seen.

Standard Oil Co. of New Jersey has an oil refinery at Parkersburg, West Virginia, from which it transports finished products to various marketing department stations on this section. An idea of navigation conditions on these waterways in the winter months is given by the following experiences of Standard Oil Company's barge fleet on the Ohio River during the month of January, 1926.[1] The fleet had been tied up during the greater part of that month due to low water and the presence of ice in the rivers. Toward the latter part of the month, however, a few warm rainy days caused the Ohio to rise rapidly and carry downstream large floes of ice, which, if not anticipated and guarded against, can cause great damage to equipment operated on the river. Immediately after the danger from ice had passed, it was necessary for the fleet of barges to make prompt deliveries to certain distributing stations while an open and navigable stage of the river prevailed, and the first trip was made to Huntington, located just up-stream from the Kentucky line.

By this time the Ohio had swollen to such an extent that it was possible with the aid of the current for three barges in tow of a sternwheel steamer to make the trip from Parkersburg to Huntington, a distance of 123 miles, in twelve hours. Upon arrival at the discharging point, it was found that the water had covered the uppermost discharging connection ashore, notwithstanding the fact that this is located twenty-five feet above the lowest connection, which is installed at the pool or ordinary stage of the water. This connection necessitated making emergency discharging con-

[1] Abstracted from an account appearing in "The Lamp" house organ of the Standard Oil Company.

nections on the bank, and although somewhat unusual it serves to illustrate the problems of the river steamboat man on the Ohio.

In the face of such operating conditions, the Ohio River barges of Standard Oil Co. transported over a quarter of a million barrels of products during 1925. The Mississippi from St. Louis to New Orleans is approximately 1152 miles in length. The depths of water and the courses of the channels vary with different seasons of the year, and between St. Louis and Memphis the channel is frequently not over 6 ft. in depth. This was the route over which the famous old packets of the 'fifties and 'sixties of last century did their racing. The big passenger packet of the present day has almost disappeared except in certain localities, while an attempt to revive old traditions is still kept up in the running of large excursion vessels, comparable with the Hudson Day Liners, from river ports like St. Louis. Inland Waterways Corporation has, however, done much to develop freight traffic on the New Orleans–St. Louis route during the past few years and during the fiscal year ending June 30, 1925 they moved on this route 261,277 long tons of grain, 174,966 long tons of bauxite and 156,897 long tons of sugar. Grain cargoes are downstream, sugar and bauxite upstream. General cargo is also handled in smaller quantities.

The Black Warrior System and its New Orleans connection is, as far as cargoes are concerned, comparable with the Ohio System. Coal from the Black Warrior Basin and steel products from the Birmingham district form the principal downstream cargoes, while manganese ore and sulphur are handled upstream. From the confluence of the Black Warrior River with the Tombigbee River there is a depth of about 6 ft. of water to a point about 385 miles above Mobile. This river has 17 locks.

The foregoing has described features of the principal inland waterways. Many of the coastal "sections," e.g., San Francisco Bay, Puget Sound, the Chesapeake and Delaware estuaries are virtually inland waterways, and each possesses its own peculiar traffic and characteristics. Especially is this the case with San Francisco. All, however, have direct communication with the open sea through straits or narrows and hence have been treated as part of the coast lines.

Survey of American Ship Types

Covers a Total of Fifty-Seven Different Kinds of Specialized Craft

American ship types have been evolved for the purpose of carrying passengers and freight on the routes and waterways discussed in the foregoing chapters, which were in effect a cursory maritime geographical survey. The coasts by themselves present almost infinite variation both of climatic conditions and of outline. Different districts with their own physical conditions naturally react upon ship type characteristics, and to take a particular example, a ferryboat in the New York district although maintaining the same general principal features of design as a similar vessel operating on San Francisco Bay has many minor differences, while a Western River ferryboat is entirely different from either. Or consider a vessel operating on Long Island Sound and her opposite number plying on Puget Sound; although each fulfills essentially the same rôle in the scheme of transportation, yet each has its characteristics of locality. In constructing arbitrary compartments, therefore, into which domestic ship types can be placed, one must realize that none of these compartments is absolutely watertight. There must be inevitably borderline cases in each compartment. For example, a coastwise passenger and cargo ship is in some cases separated only by a very thin wall from an ocean-going ship; a bay and sound steamer is under many circumstances a coastwise ship and so on. This does not mean that cosmos must be evolved from chaos in order that clear presentation of the characteristics of domestic ship types may be given, because, having in mind the borderline cases we can consider these types under the following heads:

Coastwise Ships

Coastwise Ships include all ships scheduled on port to port runs along the coast by outside passages, with passengers or freight or both. Fishing craft are really coastwise but owing to their special characteristics they should be considered separately. Coastwise

Coastwise ships, like this Munson motorship, girdle the extensive seaboards.

ships range in size all the way from large ocean-going type vessels on the New York–San Francisco run down to comparatively humble craft of about 300 ft. in length running between Boston and Maine coast ports. They carry the millionaire realtor to Miami and the west coast miner to his camp. They bring north the fruits of Florida and south the lumber of Oregon. On some routes (e.g., Portland, Ore., to San Francisco) they equal, if not outrival, the railroad for speed. Coastwise ships girdle the seaboards taking passengers for pleasure, for business, and freight. Some of the ships operating are old, some obsolete, others are as up-to-date as anything on ocean routes.

Then again, some coastwise ships operate to the Caribbean Islands in the winter months. In fact the present tendency, exemplified particularly by the Clyde Line, is to build large fine ships capable of Winter cruise work.

Sound and Bay Ships

Most Sound and Bay Ships are confined to the East and North western seaboards and navigate Long Island Sound, parts of the Maine coast, the Hudson River (which although a river may be ranked virtually as a sound), the Delaware and Chesapeake and their tributaries, San Francisco Bay and neighboring waters, and Puget Sound with its neighboring waters including

Sound ships like this fine Eastern Steamship Co.'s vessel navigate the Maine coast.

the Inside Passage to Skagway in Alaska, from Seattle and Vancouver. Some of these ships operate with passengers and freight or with freight only throughout the year and some operate under special conditions in certain districts, of which San Francisco Bay is the best instance. Here, for example, are a number of shallow draft tank ships used for oil and gasoline distribution throughout the San Francisco Bay district. As shallow draft tankers they are not unique, as bay ships they are not unique and yet it is impossible to confuse a San Francisco Bay tanker with an oil barge operating on the Hudson River. On the Sacramento and San Joaquin Rivers emptying into Suisun Bay will be found sternwheelers similar in many details to those on the Mississippi and Ohio Rivers. Many of these vessels are literally

floating warehouses, carrying all sorts of package cargo to the farmers in the delta lands of these two rivers. Sternwheelers are of course necessary owing to the comparative shallowness of the rivers — sometimes not more than three feet. Other bay and estuary steamers, like the large Hudson River Day Liners are intended for pleasure work only during the summer season — May to September — and for the rest of the year they are laid up. These ships are the senior members, from the point of size, of a large family of miscellaneous brothers of varying sizes and ages engaged in the pleasure trade, some of which are pleasure-worthy palaces while others are age-rotten rattle traps. Puget Sound possesses a variety of craft engaged in freight service to the local canneries and for general cargo work, some of which were specially designed for the work while others have been most definitely improvised to the benefit of the cargo capacity and the detriment of stability. At the other end of the scale, one finds in this district some of the finest and swiftest passenger carriers in the world.

Harbor Ships

Harbor Ships include ferries, towboats, car floats, oil barges, work boats, floating derricks, and dredges. This is a mere outline because each of the types mentioned under this head has infinite variations of characteristics with differences of duty. American ports probably contain more service craft per square mile of area than any other harbor in the world with the possible exception of the ports of Rotterdam and Hamburg. This is partly enforced by physical conditions as well as fostered by realization on the part of authorities of the extra efficiency which a good supply of tugs, barges and work boats can give to a port. A large proportion of tugs in the port of New York is employed in railroad duties since the peculiar geographical situation of Manhattan Island requires the transfer of much freight from the mainland. These tugs handle barges known as car floats. Tugs take tows of barges empty up the Hudson River to Troy and Albany and return with them loaded. Tugs move loaded oil barges alongside the trans-

atlantic liners; they also assist in moving ships to their piers. Larger towboats move much traffic coastwise in barges and scows they tow, sometimes by the outside and sometimes by the inside routes, i.e., via the sounds. Eastern seaboard tugs move large quantities of coal from Norfolk and Baltimore in tows of three or four large barges. West coast towboats operating in the

Cars are transported to the mainland of British Columbia in special car floats.

Columbia River and Puget Sound districts handle quantities of lumber; they also tow floats which carry railroad cars across from the mainland to Vancouver Island, while east coast tugs operate large floats with freight cars between Cape Charles and Norfolk. Floating derricks form part of the equipment owned by the railroads and by private companies for moving heavy loads quickly, while workboats include a miscellaneous collection of self-propelled barge like craft which perform odd jobs within the vicinity of harbors.

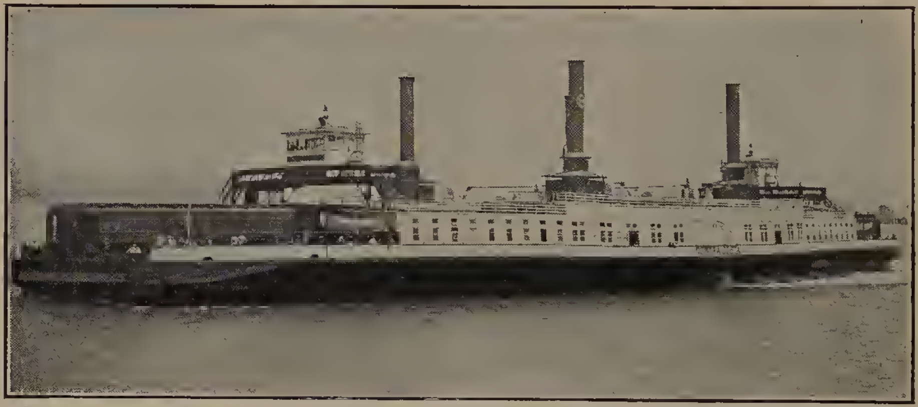
Fireboats are units of harbor fleets of the utmost importance. In dimensions they are comparable with towboats and their equipment consists of centrifugal pumps taking water from the river and discharging it through nozzles placed at strategic points on the deck.

As a matter of fact railroads are really the biggest owners of harbor craft and this is particularly the case in a harbor like that of New York where towboats, barges, ferries, derricks, and fast

excursion steamers all come under their management. The tow-boats are required to operate the car floats; the ferries are used to transfer passengers and vehicles to railroad terminals on the New Jersey and Long Island shores; the derricks take care of heavy engineering shipments and the like, and the fast excursion steamers run with peak loads seeking relief from the crowded city upon even more crowded beaches.

Ferries

Ferries provide sufficient material almost for a book by themselves owing to the diversity of their work and characteristics. The majority are employed in transporting passengers and vehicles



Large special ferries, like the Southern Pacific R.R. Contra Costa, transport Pullman cars and freight trains across an arm of a bay.

between harbor terminals; some are reserved exclusively for vehicular traffic. The largest and fastest ferries are some of those operating on San Francisco Bay, the next largest run between Battery Park, New York and St. George, Staten Island. In the South and West there are a few large very special ferries which transport a locomotive and train of Pullman cars across a river and across an arm of a bay respectively; in the Great Lakes there are definite train ferries with ship type hulls; and in the Mississippi below New Orleans there are double hulled catamaran ferries. Western River ferries and some ferries operating on the west coast rivers differ very materially from those found

in any other part of the country. These vessels cover a wide range of hull design and propelling machinery, the latter ranging from 40 years old walking beam engines with Corliss valve gear to electric motors taking current from Diesel generators.

Dredges

Holland has often been called the mother of dredge construction, but there is no doubt that America occupies a good second place. Harbors which handle some of the largest passenger liners in the world have to be kept in a state of 100 per cent efficiency, and suction, pipe line and dipper dredges are extensively employed. The Ambrose channel leading to New York, the approaches to the Panama Canal and parts of the canal itself, harbors like Galveston where a valuable artificial island has been built up behind Galvez Island from the dredgings of Galveston harbor, the fairway to the port of Portland, Ore., maintained by the largest pipe line dredge in the world, and the canalization of some of the Western Rivers are all examples of what dredge work has done for the waterways of America. Here also more ingenuity has been shown in regard to the choice of operating machinery than in Europe and elsewhere and particularly praiseworthy is the recognition which has been given to electricity for dredge work. The first all-electric dipper dredge was completed in an American ship yard in 1925. Other Diesel and Diesel-electric dredges are in operation in various parts of the country and are proving their economy of operation.

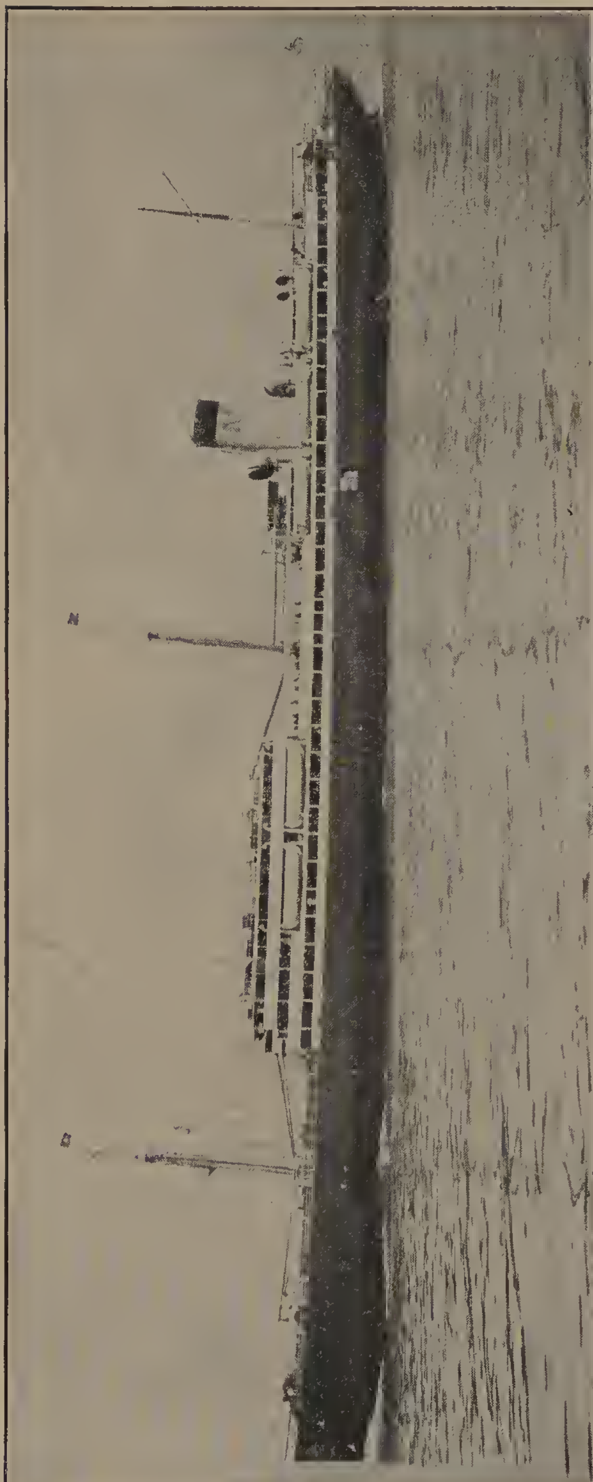
Light Vessels

Light vessels are included in the Harbor Craft compartment on a somewhat slender excuse — the excuse that their efficient functioning is the means of ships entering and leaving harbors safely. American light vessels are as different from, say, German lightships as the latter are from British lightships. They are sturdy self-propelling craft — the more modern being Diesel driven — and they maintain some of the most exposed stations in the

world. Nantucket — end of the transatlantic run — Diamond Shoals — first landfall on the way up from the Carribbean, Golden Gate — guarding San Francisco harbor, are well-known examples. They vary in size and power according to duty.

Great Lakes Ships

Great Lakes Ships consist very largely of bulk freighters designed for the speedy loading and unloading of ore, coal, and grain. We have seen already something of the conditions prevailing on the Lakes and how they affect the design of these ships. Great Lakes bulk freighters are probably the most severely specialized tonnage in the world for in very few other ship types have the exact requirements of service been worked out to such a fine art. The smaller freighters which navigate the Welland Canal and in some cases coastwise during the winter months are often subjected to harder conditions than their larger brothers because they have much more canal work, and the custom is to steam at full speed into the locks, the man in the wheel house trusting to the man operating the engines to obey his "stop" signal sufficiently promptly enough to avoid accident. The Great Lakes area boasts its passenger fleet and here again if it has not produced types which are the last word in efficiency it has certainly contributed something to shipbuilding science not to be found anywhere else. Cleveland and Buffalo can talk in terms of sidewheelers of 11,000 i.hp. with a gross tonnage of 6380, a length b.p. of nearly 500 feet and four complete superstructure decks above their main strength deck. Then there are also passenger ships with machinery aft, direct developments of the bulk freighter; in effect bulk freighters with decks in their holds and superstructures above their main decks. It is only on the waters of the American continent that you can find passenger vessels with propelling machinery all aft, and Matson Line of San Francisco are the only owners of ocean going ships who adopt the arrangement of placing the machinery abaft of amidships in their passenger ships. In some of the large transatlantic liners it



Matson Line of San Francisco have magnificent passenger ships on the Hawaii run with machinery aft. They are the only owners of passenger lines in the world to do this and their ships are thus as efficient as they are distinctive.

is true the steam turbines are considerably abaft amidships but then the boilers are forward of this.[1]

Within the same waterway section as the Great Lakes is the St. Lawrence River and Estuary which although not a United States domestic waterway may be considered as such for purposes of this book because it carries numbers of the smaller Great Lakes freighters — known usually as canallers from the fact that they operate in the Welland and St. Lawrence canal systems — as well as numerous pleasure craft towboats and workboats of typically domestic type. Among such, mention may be made of vessels designed for tourist service between Montreal and Quebec and between Quebec and the Saguenay River.

Western River Ships

An attempt was made in the previous chapter to show something of the condition of things likely to exist on the Western Rivers for some years to come as well as on the New York State Barge Canal and it was seen that the traffic was principally of a bulk nature. Barges of non self-propelling nature are the principal participants in this form of transport and they are usually handled in tows of varying numbers depending upon the conditions of the stream and the power of the towboat. To be correct, one should speak of "pushes" of barges and of "pushboats" rather than of tows and towboats since there is no towing in the accepted sense of the term done on the Western Rivers. Some pushboats are of tunnel stern type and more are of sternwheel type. Some day one system will definitely prove itself to be the better. The advantages and disadvantages of each type are discussed in a later chapter. Some barges are self-propelling and one company has even gone to the length of making a barge self-unloading too. Everywhere the keynote is minimum draft and hence the tendency is to carry freight *outside* the hull proper. This has led to the development of a particular type of box barge in which freight is loaded and unloaded from the "box" by means of top and side doors.

Package freighters — what few there be — are mainly of sternwheel type and although they have a certain aesthetic beauty all their own they are but sorry descendants of the grand old Mississippi packets of fifty and sixty years ago. Usually the cargo is carried on deck and a few passengers are accommodated on a deck above the cargo deck. The nearest approach to the big

The Western Rivers have their own particular type of mobile ferryboat.

packets of the "grand old days" is to be found in the big sidewheel excursion steamers operating from cities like St. Louis. Some of these manage to combine an overall length of 300 feet and five decks with a draft of only 5 feet. These ships retain the old packet boat arrangement of very large sidewheels well abaft amidships. Nature has a playful way of placing tree trunks and other obstacles to navigation in the western river fairways and this demands the presence of snag boats — which are really sternwheelers with a sheerlegs or boom derrick over the bows and a powerful winch — to remove such obstructions. The Corps of Engineers of the Army usually takes care of this and they employ a similar type of craft for the same purpose in the Puget Sound district. Dredges are also necessary adjuncts to Western River navigation, the sand pump type being chiefly employed. Then

the Western Rivers have also their own particular type of ferryboats to which attention is directed later. They differ entirely from the ferryboats found in harbors because they are side loading as contrasted with end loading and in a few special cases a double hull catamaran principle is used. The sternwheel is the favorite method of propulsion even when, as is the case with some of the more primitive ferries still in existence, a horse constrained to move in a circle is the prime mover. In the sideways loading they bear a distinct resemblance to ferries operating on European waterways. For heavy traffic the method is very inefficient.

New York State Barge Canal

The New York State Barge Canal is a waterway of contrasts. It floats very modern Diesel-electric barges designed to operate on the lakes (they run from Duluth to New York with grain)

Modern barges, General Electric equipped, take full advantage of the Barge Canal.

and also on the St. Lawrence and coastwise when lake navigation is closed, and it carries also archaic, high sided, old wooden barges which date back several decades. These are Erie Canal type barges. Operating chiefly on the Hudson between New York and Albany–Troy are wooden barges of varying sizes in some of which cargoes of bricks are carried — these barges are box shaped with sloping ends and carry their cargoes entirely on deck — while

others with quarters for crew and their families either amidships or astern — may carry sand, gravel, or other Hudson cargoes. These barges, which by reason of their crew's quarters are reminiscent of the barges working on the big European waterways, are made up into "tows" during the day ready for transportation in the evening up or down the river in tow of powerful screw tugs. The number of craft to a "tow" depends solely upon the maximum power of the towboat as well as, of course, upon the traffic available.

Stakeboats, box-shaped barge structures having an "office" on deck, are moored by heavy mushroom anchors at convenient places not too near a fairway and to these boats, units of the tow are moored while other units are being assembled. Smaller towboats tow the barges from their piers or terminals to the stakeboat.

Modern steel barges are being introduced now on the State Barge Canal and, as has been mentioned, many companies are introducing their own barge lines in order to control their own traffic to and from the Lakes to their own New York piers.

Sternwheelers

Sternwheelers are not confined to the western rivers although they are used there in greater numbers than elsewhere. Puget Sound has them as we have seen, the Sacramento and San Joaquin Rivers use them, the Columbia River employs them as towboats as well as for package and passenger freighters, between Portland and Astoria, and on various shallow tributaries to the main Columbia stream. Each district, however, has its own peculiarities of design. A San Joaquin vessel's bow differs somewhat from the Western River boat's bow. Some Columbia River and San Joaquin packets' sternwheels are partly housed in like sidewheels. The tendency, too, is for sternwheelers operating outside the Western Rivers to have a wheel house far forward. Some vessels have ship shape hulls and bulwarks; others wide decks on a flared out hull. . . . It would be possible to go on forever describ-

ing various little refinements of this nature. The sternwheeler is a veteran, and many people say she should be abandoned gradually in favor of the Diesel driven tunnel stern vessel. It will take a long time to do this. The Diesel engine certainly is a most economical form of propulsion for all river work with its various lay-bys but whether the vessel with screws working in tunnels is a better proposition for all shallow draft work it is a

Some Columbia River type packets' sternwheels are partly housed in. This Canadian Pacific Co.'s ship is a good contrast to Western River boats.

little difficult to say. The sternwheel has the advantage of being easily repaired and of being able to go almost anywhere.

The foregoing remarks have outlined briefly the principal ship types which have to be covered in this book, and should be studied in conjunction with the table of comparative analysis and the maps. This may on a casual glance appear rather complicated and alarming but is not so when studied in detail. Types have been treated in the table as far as possible geographically so that it can be seen exactly what ships are required by and used in coastwise, bay, sound and estuary, harbor and inland waterway work respectively. Some types, such as for example ferries, duplicate themselves in practically every section; others, such as large self-unloading bulk freighters are peculiar to one section. It should be emphasized, therefore, that the comparative analysis

definitely sets out to show the types in relation to one another.[1] No useful purpose is served by flinging down an apparently unconnected mass of ship types with location in the family tree utterly obscure. Even a casual glance at the [2] table, however, will give an idea of the large number of domestic types in existence and the outsider who declares glibly that America has no shipping can surely need no more convincing contradiction to his statement.

[1] As with ocean shipping in the author's "Merchant Ship Types." Van Nostrand Co., New York.

[2] Letters and figures in the sideheads of chapters which follow refer to corresponding letters and figures in the Comparative Analysis.

All Types of Coastwise Shipping

Total Nearly 4,000,000 Gross Tons of American Built Craft

PRACTICALLY 4,000,000 tons of shipping is engaged in coastwise transportation business and about 50 per cent of this runs in the coast to coast trade via the Panama Canal. The whole of this tonnage has been built in American shipyards and is American manned. Coastwise shipping is more important to the community, more diverse in its cargoes, and more versatile in its ship types in the United States than in any other country in the world. The reasons for these conditions are not hard to seek; indeed, they must be obvious from the study of coastwise geography which occupies an earlier chapter of this book. Coastlines are not only long, but they are diverse in formation and in physical characteristics. It may be urged that in view of this, certain portions of the coastwise routes naturally become limbs, as it were, of services commencing in some foreign country, and this is true to a certain extent; but even so, owing to the wise provisions of Congress, carriage of freight and passengers between two points on the coast line is absolutely restricted to American owned tonnage.

Coastwise services are the oldest shipping services in the world since they date back to the first voyagings of primitive man in his wooden dugout. They have always been important to the North American Continent from the beginnings of colonization on the narrow eastern seaboard strip. In a new, unknown, and unfriendly country, long before the railroad was dreamt of, the colonist found that water communication from settlement to settlement was easier than land transportation, even though, to modern eyes, the small ships used appear anything but safe. At the present time coastwise services flourish generally only when

they can show, for the transportation of a particular type of individual or class of merchandise, some marked superiority over railroad facilities. For both freight and individuals, the ship gets the traffic when:

Coast railroads are non existent (e.g., certain parts of the Oregon and Alaska coast lines).

Railroads provide an indifferent service.

The ship is definitely superior to the railroad.

The distance is so great that there is comparatively little difference between the time taken by the steamer and the railroad.

In the latter case each party stands an even chance of getting the business theoretically, although the odds are invariably on the railroad because of a lack of appreciation on the part of some shipowners of the needs of the traveling public, and not only of their needs but also of the little extra attentions and courtesies which will attract not only the tourist but also the business man away from the railroad. Such people have to be assured, before they will buy steamer tickets, that they are going to get hotel comfort at sea and that they can have speedy, restful transit. These points have been realized to the full by one man, although there are indications that others are now rapidly falling into line. That man is H. F. Alexander, president of the Admiral Line and owner of the ship named for him, one of the fastest ships in the world and one of the finest vessels an American shipyard has ever turned out. *H. F. Alexander*, the ship, does the run from Seattle to San Francisco on a schedule of 38 hours, the fastest train doing it in 36 hours, and average trains in 42 hours. H. F. Alexander, the man, has done more to revolutionize coastwise passenger traffic than any other shipowner in the world, and in so doing he had to upset many cherished traditions as to fares, arrangement and luxury of accommodations. As he himself says in an article contributed to "System" in 1925:

"Even six or seven years ago the discriminating traveler between the large cities of the Pacific Coast traveled exclusively by rail. He had to; in all honesty no one who was not willing to put up with a good deal would travel between, say, Seattle and San Francisco by

water. The traffic at that time was largely made up of people who could not afford to pay rail fares, plus the rather rare individuals who are so fond of traveling by water that they would put up with the loss of time and the lessened comfort to indulge their hobby.

"Chiefly our passengers were migratory laborers on their way from the lumber camps of Puget Sound to the orange groves of southern California, and the like. Tradition had it that this was the only class of people who would travel by water along the coast.

"Meanwhile transoceanic travel had been increasing in luxury, in speed, and in cost. We felt that a similar development must be attained along the coast."

This is the line upon which future coastwise passenger ship development must take place. It is possible on the waters of the North American Continent because the long distances and excellence of the harbors allow the transatlantic liner to be copied in miniature. British designers have until recently imitated the transatlantic liner in ships which run across the English Channel — with complete success from the naval architect's point of view and from speed and power requirements but with very bad arrangements as far as passenger accommodation is concerned. Cabin space is badly and inadequately arranged because of limitations of dimensions, and the paring of these to a minimum for excessive speed. On U.S. coastlines there are no such limiting restrictions on dimensions and this permits of the development of a fine, fast type of ship.

Where it is a question of the transportation of freight only along the coasts, the ship has almost a monopoly of the trade at the expense of the railroad, in the case of bulk commodities such as oil, for which there is a continuous demand and supply and hence speed is not a primary consideration. Furthermore crude oil or its distillates can be transported in bigger quantities at one time in the hold of a tanker than in a train of tank cars on a railroad. The same applies also to such commodities as coal, coke, and sulphur. For delicate or perishable freight, the amount given to the shipping man in preference to the railroad man depends upon the speed of the ship and on the type of accommodation offered. If passengers are being carried at the same time, it

is reasonable to assume a speed of over 12 or 13 knots, and, with a displacement tonnage of 7000–8000 tons, a type of ship, known in ocean-going parlance as "intermediate," results. Much of the fruit and vegetable produce of Florida, Georgia, and the Carolinas reaches the New York markets in ships of this type.

In most types of water transport, railroads themselves own ship tonnage which form connecting links in a chain of service. Possibly the most complete example of this is the Round-the-World ship-hotel-railroad service of the Canadian Pacific Railway which incidentally operates fast day and night steamers on Puget Sound. One of the few railroads owning and operating steamers in coastwise services is the Southern Pacific Railroad whose fleet regularly runs from New York to New Orleans and to Galveston, Texas. The ships carry passengers and freight, and since both New Orleans and Galveston are on the Southern Pacific system, passengers as well as freight can be booked through on the same system to points in the South West and West as far north as Portland, Ore. Here, then, is an interesting case of a sea service acting as a useful adjunct to a railroad service. Sea services link the north of the continent with a railroad covering the south and the west.

The Pacific seaboard presents some rather different transport requirements to the Atlantic. That lengthy island-fringed channel embracing Juan de Fuca, Puget Sound and the Inside Passage, as well as the Oregon coast itself has intense lumber and canning activity, resulting in the lumber schooner — now no longer a schooner in the accepted sense of the term — the coastwise tankers and packet craft. From Seattle to San Francisco and from San Francisco to San Pedro and San Diego, the coast line is such that it permits of the passage of fast passenger ships running in successful competition with the railroads. The Panama Canal has proved of immense value in linking the two seaboards and has caused a large intercoastal traffic to spring up, in which Mexican and Central American ports are tapped. Coastwise passenger movement is now linked by large ships of ocean-going type which operate between New York and San Francisco via intermediate

ports in about 18 days, and a large business is carried on at all seasons of the year.

Table of Intercoastal Ship Characteristics

Coast-to-Coast Services — Passenger and Freight Type

Date	*Regd. Dims.* L × B × D	*Draft*	Power Speed	*Passengers* 1st	2nd	3rd	Gross Tons Cargo Capacity
1927	600 × 80 × 52	32	17,000 s.hp. 18	362	360	...	22,000 7,800 tons
1904	600 × 65.3 × 2	33.5	10,000 i.hp. 14	246	...	1146	13,639 549,864 cu. ft.
1898	360 × 50 × 19.9	25.5	5,000 i.hp. 14	189	...	...	5664 256,000 cu. ft.
1915	380 × 50 × 32.5	24.75	3,350 i.hp. 12½	108	...	165	5641 198,910 cu. ft.

Coast-to-Coast Services — Freighters

Date	*Regd. Dims.* L × B × D	*Draft*	Power Speed	Cargo Capacity Tonnage
1922	445 × 60 × 59.8 Shelter decker	28 ft. 7 in.	4,500 i.hp. 12	612,870 cc. bale 11,200 tons dwt. 5,600 gross
1916	425 × 57.3 × —	31 ft. 8 in.	3,500 i.hp. 13	592,360 cc. holds 12,614 tons dwt. 7,820 gross

Coast-to-Coast Type (*A*)

Coast-to-Coast services, as we have seen, followed directly on the opening of the Panama Canal. They are therefore the youngest of all American domestic services and are carried out almost entirely by vessels of ocean-going category. Freight forms a large proportion, in fact, the larger proportion of the coast-to-coast

traffic, but there is also a considerable passenger movement, chiefly of tourist type, and by scheduling the ships en route from New York to San Francisco to call at Havana and ports on the Mexican coast a journey of considerable interest can be offered to the public. It is obvious that such ships must be of an intermediate (i.e., passenger and freight carrying) nature and this will be found to agree with the foregoing table on page 52. All the ships listed therein, selected from fleets at present operating on the coast-to-coast routes are intermediate ocean-going ships and, with the exception of the first one mentioned, none were designed for the service, all being intended for transatlantic work. The first mentioned was a specially designed electric ship for the New York–San Francisco route by International Mercantile Marine Corporation, but she is capable of functioning on almost any of the other routes served by the company. Comfortable and up-to-date passenger accommodation is of increasing importance to this route and with this must be combined speed. The average time taken by the Panama Pacific Line of the International Mercantile Marine Corporation to cover the 5200 miles between New York and San Francisco is 15 to 18 days including stops at intermediate ports. An increase of speed in a passenger and freight ship means that a faster service can be offered the public and to shippers and that a better class of freight can be carried. Most of the ships at present operating in the fast coast to coast service have refrigerated space in which the fruit of California can be brought to New York. The large I. M. M. ships designed for the service are electrically propelled, current being supplied by turbo-generators. Refrigerating machines run most economically when electrically driven, and this fact has been brought out clearly by United Fruit Company in two Diesel-electric banana carrying ships which operate between Puerto Barrios, Guatemala, and New York.

One of the most difficult matters to allow for in the design of passenger ships for coast-to-coast service is the changes of climate to which they are subject, especially in winter. Leaving New York on, say November 5, the passenger is in the heat of Havana

by November 9, and a few days later in the tropical Canal zone — a change more sudden than in the case of ships running to the Far East from British Ports, on which routes a comparable state of affairs exists over the first stage of the voyage. A well proportioned heating and ventilating system can be made to take care of this contrast; otherwise it seems improbable and unnecessary that any very special type will be evolved solely for coast-to-coast passenger service, and passenger-cargo liners will continue to be employed.

Intercoastal Freight (*A1*)

Intercoastal freight varies both in quantity and in type and with certain exceptions — bulk cargoes — can be classed as general cargo. Most commodities are exclusively uni-directional (e.g., Pacific-to-Atlantic) while a few are moved in both directions. Others, such as fruit, are occasional or seasonal cargoes. The table shows the principal cargoes handled in either direction and also gives the total quantities in tons of 2240 lbs. passing through the Panama Canal in one particular month, the actual figures being taken from *Panama Canal Record*. It will be seen that one of the most important Pacific-Atlantic cargoes is lumber, of which no less than 218,260 tons passed through the canal in 28 days. This means, assuming the lumber to be carried in ships of about 7000 tons cargo carrying capacity approximately three to four ships per month of 28 days, or one ship per week with a lumber cargo from a Pacific port to an Atlantic port. Other important cargoes of a general nature comprise such commodities as canned fruits, flour, canned fish, dried fruit and beans. Crude oil and refined oil comes in a class by itself. Tonnage handling it has the usual characteristics associated with ships which carry oil in bulk,[2] i.e., machinery aft, centerline bulkhead — two in the case of ships carrying refined oils — expansion trunks and in certain cases summer tanks. Bulk oil freighters in the intercoastal trade are usually of ocean-going type. For shorter coastwise runs,

[2] See the author's "Bulk Cargoes." Van Nostrand Co.

e.g., Bayonne, N. J. to Portland, Me. or to New York, they are small ships with special characteristics, e.g., navigating bridges aft, electric propulsion, etc. A total of 271,671 tons of crude passed through the Canal from West to East in the period under consideration.

The largest return Atlantic–Pacific cargo comes under the heading of manufactured iron and steel goods of which a total

Coastwise tankers, like Hawaiian Standard of Standard Oil Co. of California, have special arrangements and characteristics for their heavy duties.

of 88,839 tons passed the Canal in the period under consideration. Most of the East–West cargo, in fact, is of manufactured variety — machinery, railroad material, textiles, tobacco, lubricating oil, automobiles and sugar. All of these commodities, as well as the West–East cargoes, it will be noted, are either of the continual supply and demand type such as canned fruit, flour, beans, etc., or of such a nature as to make their shipment by sea an easier matter than by land. Included under this head are railroad material, heavy castings and automobiles. Fresh fruit only totals — in the Pacific–Atlantic cargoes — the remarkably low figure of 940 tons, showing that the trend still is to ship much of the more perishable freight by the railroads. There is no reason, however, why a service of fast freight or passenger freight ships with ample refrigerated space should not capture a large portion of the inter-coast fruit trade.

Freight ships engaged in the trade vary between about 7000

and 12,000 tons deadweight capacity and are of general cargo type with two or three tiers of 'tween decks. They present few special features of design outside their ocean-going cargo vessel characteristics, except a larger number of derricks which enables them to take care of lumber cargoes. The first example quoted

Representative Month's Traffic in Intercoastal Trade

Atlantic-Pacific		*Pacific-Atlantic*	
Commodity	*Tons of 2240 lbs.*	*Commodity*	*Tons of 2240 lbs.*
Iron and steel goods	88,839	Crude oil	271,671
Tin	18,617	Lumber	218,260
Sulphur	6,163	Refined oil	124,462
Lubricating oil	2,970	Canned fruit	12,278
Tobacco	1,595	Iron ore	3,686
Iron	2,050	Flour	6,882
Machinery	4,454	Hemp	1,062
Railroad material	2,376	Copper	5,667
Textiles	4,199	Lead	2,340
Fullers earth	1,040	Beans	4,851
Glass	2,087	Canned fish	8,568
Coal	2,361	Skins and hides	1,317
Cement	1,282	Fruit, Dried	3,052
Chemicals	1,545	Fruit, Fresh	940
Automobiles	2,988		
Caustic soda	6,163		
Sugar	1,132		
Rubber, Manufactured	1,270		
Phosphates	650		

in the cargo ship section of the table on page 52, for example, has in all 22 derricks, 8 on the foremast, 8 on the mainmast and 4 and 2 on two sets of derrick posts forward and aft of the midship house respectively. These with their winches serve 4 main hatches and 2 deep tank hatches. A cargo vessel of ocean-going type and similar cargo capacity having 4 main hatches, has in all 11 derricks, 5 on the foremast, 4 on the mainmast and two on the poop worked from derrick posts surmounted by cowl ventilators. Intercoastal cargo ships have usually one or two tiers of 'tween decks to enable them to handle the miscellaneous cargoes mentioned in the table. Since they continually and regularly use the

Panama Canal they also naturally have all points taken care of in their design which will enable them to secure a minimum Canal tonnage measurement.[3]

Hawaiian Islands Trade

Linked very closely with intercoastal trade is trade with the Hawaiian islands which comes under the coastwise laws. Many cargo ships which operate ordinarily between New York and San

Ms. Hawaiian Standard handles Socony products and package freight in outlying Hawaiian island posts far from her loading port.

Francisco take general cargoes out to the Islands and return with sugar in bags. A considerable proportion of the traffic to the islands is in the hands of the well-known Matson Navigation Company of San Francisco, which company, as has been men-

[3] See "Measurement of Vessels for the Panama Canal" by Emory R. Johnson. Washington.

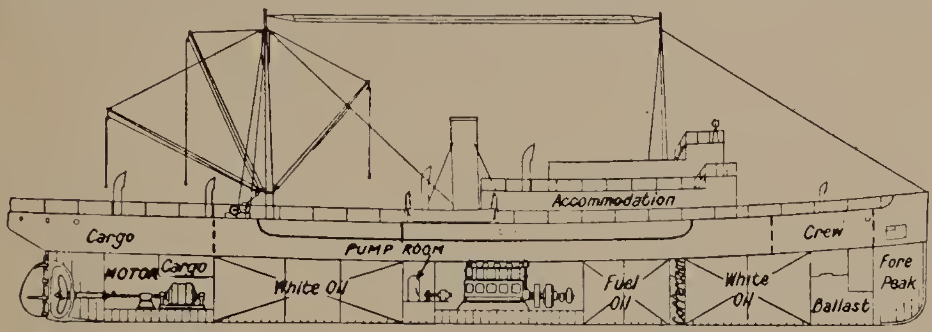
tioned, is unique in having the only large ocean-going passenger ships in the world with engines aft.[1] These ships are easily comparable in size (the largest carrying over 200 passengers and 10,000 tons of cargo), with the passenger vessels operating in the intercoastal runs. They are of a design which has been specially developed for the service and the position of their machinery gives absolutely clear passenger decks. Most Matson freighters as well as the large passenger vessels, in fact, have their machinery aft. *Malolo*, latest vessel for this company, a large turbine driven ship, however, is of conventional type with machinery amidships. It is thought that she has been designed with a view to transpacific service to Australia.

Requirements for the crude petroleum trade and for the distribution of its distillates in the islands led the Standard Oil Company to place on service a small, very efficient tanker, *Hawaiian Standard*, in which the machinery was placed amidships. This is an unusual arrangement for such ships, for various reasons, chief among which is the desirability of securing continuity of tank space and the inconvenience of having an oil tight shaft tunnel running through the tank abaft the machinery space. *Hawaiian Standard*, however, was required to carry parcels of oil of different flash points and specific gravities to different destinations in the islands, as well as a certain amount of general cargo. It was not of paramount importance, therefore, to secure continuity of tanks, while the adoption of Diesel-electric drive gave a small generating compartment amidships and no space was absorbed abaft this compartment by a shaft tunnel. Four tanks were arranged forward of the generator space — two fuel oil tanks being separated from the white oil tanks by a cofferdam. These white oil tanks and a 'tween deck cargo space were built abaft the generator room.

Coastwise Tankers (A 2)

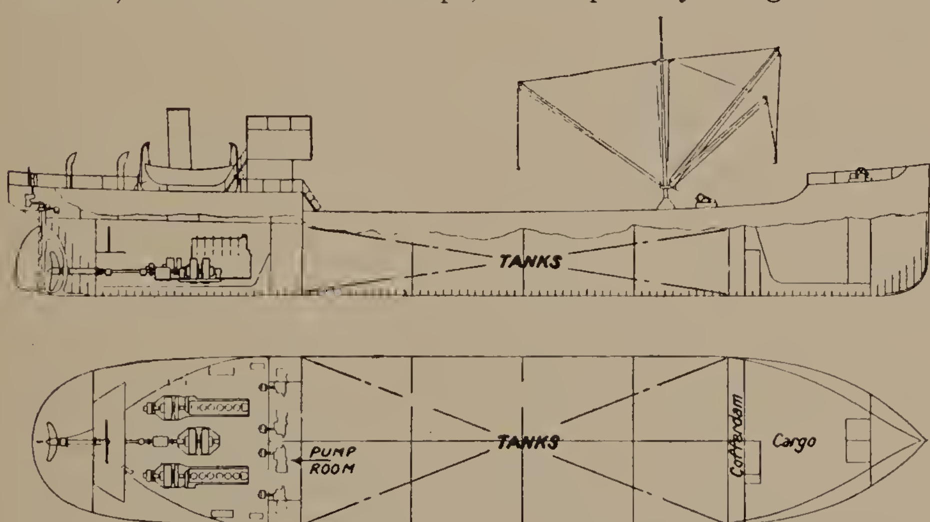
Ms. *Hawaiian Standard* has two half sisters of similar size but different arrangement and intended for slightly different service. These may be taken as good practice in coastwise tankship con-

struction, and are intended to act virtually as floating substations for the supply of petroleum products to the Alaskan mining and canning districts. They also carry a certain amount of package



Ms. Hawaiian Standard, coastwise electric tanker, measures 1875 tons deadweight and is propelled by an 800 hp. General Electric motor.

freight as would be expected, a combination which is also to be found in the shallow draft sternwheel oil carriers operated by Standard Oil interests on the San Joaquin delta and river. *Alaska Standard*, one of these two ships, was especially designed for the



Ms. Alaska Standard, a prototype of Hawaiian Standard, has the same power and capacity but all machinery is arranged aft.

trade; but *Standard Service*, the first of the group of three, was intended originally for service in San Francisco Bay. Both have their machinery, consisting of generating sets and a main propelling motor, arranged aft as the above drawing indicates.

They are members of a group of small coastwise tankers all of which have been placed in operation within the last 10 years or so, to meet the demand for efficient craft, inexpensive to operate, which can both transport crude petroleum from its source to the refineries and afterwards distribute the refined products to various substations. For the reason that most of these ships are new, internal combustion engines of surface ignition of full Diesel type are fitted for propulsion, either direct coupled to the propeller

Standard Transportation Co.'s Hudson River type bulk oil barge.

shaft or through the medium of an electric motor. Texas Company, for example, maintains a service for refined crude petroleum products from their Bayonne, N. J. refinery to their distributing stations at Portland, Maine; also between Port Arthur and New Orleans, Key West, and Tampa, with coastal motor tankers 156 ft. x 24 ft. x 11 ft. 4 in. draft. *Bayonne*, owned by Vacuum Oil Company is slightly longer, having a length of 206 ft. 8 in. x 35 ft. 6 in. beam x 14 ft. 11 in. load draft. She operates between Paulsboro and Bayonne, New Jersey. Sizes vary; in fact, motor barges built for Standard Transportation Company's Hudson River and Barge Canal refined oil distribution business, have a length of 254 ft. x 37 ft. 6 in. x 12 ft. draft, the depth molded being 14 feet. These barges are intended for coastwise service if necessary; but it is doubtful if their exceedingly low superstructure — low, in order that they can navigate the New York State Barge Canal bridges — would make them successful or sufficiently seaworthy in coastwise service. The dimensions are virtually those of a Canal freighter (Great Lakes service) designed to negotiate the Welland Canal locks.

The smaller coastwise tankers are to all intents and purposes duplicates of the San Francisco Bay distribution tankers, and all of the group, whether of the large or of the small type are small editions of ocean-going tankers having machinery aft, one or two longitudinal bulkheads, transverse bulkheads, cofferdams, pump-rooms, expansion tanks, and pipe lines (usually on deck, except in the larger type). In the smaller type, the bridge structure and accommodation is all aft; in the larger, normal practice is followed and a bridge erection with navigating officers' accommodation is built amidships. Such ships usually have also a summer tank and a large expansion tank constructed with a view to the carriage of heavy oils. A longitudinal (Isherwood) system of hull construction has been adopted with success in many coastwise tankships.

Lake-Type Freighters in Coastal Ore Trade

The iron ore trade between Cruz Grande, Chile and the North Atlantic Range while neither a domestic nor a coast-to-coast trade, has produced a very special type of ore carrier which will

Great Lakes features are found in the 20,000 ton ore carriers operating between Chile and the North Atlantic Range for Bethlehem Steel Corp.

be found on no other similar route and which is an attempt to apply the Great Lakes method of cargo handling to coastwise ships. This fleet of ore carriers, consisting of 5 American built

and owned and 2 German built and Swedish owned chartered ships with a deadweight of about 20,000 tons per ship, carries iron ore from Cruz Grande in Chile to Baltimore Md. or to Claremont, N. J., via Panama, returning light. The trip one way occupies 19 days, unloading occupying at Baltimore about 16 hours. As soon as the ships dock, their hatches — large steel

In 16 hours a full ore cargo is grabbed from the holds by Great Lakes type unloaders.

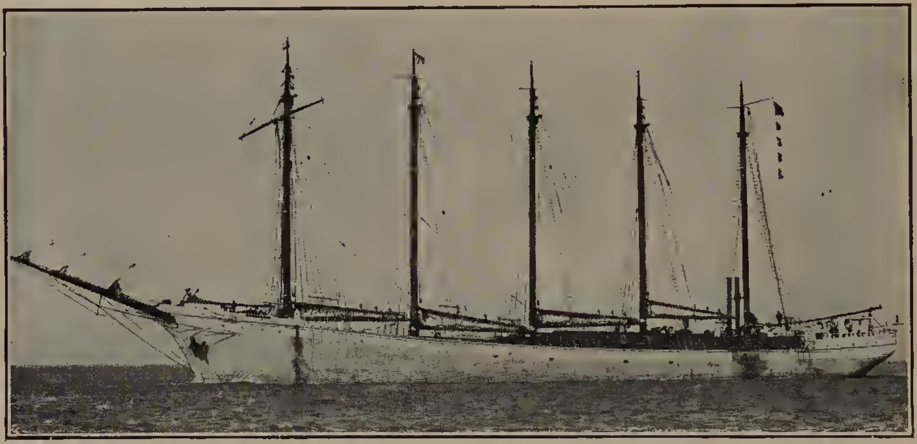
covers — are opened up and large mechanical grabs, similar to those used on the Great Lakes, remove the cargo. The ships themselves are about 550 ft. in length between perpendiculars, have a beam of 72 ft., a depth of 44 ft., and a draft in loaded condition of about 32.25 ft. The ore holds, of which there are three, occupy a total length of 360 ft. with a width of 30 ft. and a depth of 30 ft. The bottom of the hold is 14 ft. above the bottom of keel of the ship. The space outside the cargo hold to the ship's side and bottom is for water ballast. This arrangement raises the center of gravity of the dense ore cargo, a desirable feature. In an ordinary vessel the center of gravity, if the holds

are loaded with ore, is much lower than if they are loaded with a general cargo. The net effect of this is to lower the center of gravity of the whole ship and hence to give it excessive metacentric height. This increases the stability but produces a dangerously short period of roll in a seaway. The consequent rapid reversals of motion tend to produce severe racking stresses in the structure of the ship. The design adopted obviates this undesirable feature and secures long clear ore holds out of which cargo can easily be taken by means of the grabs. These ships have been built specially to suit American requirements to work in conjunction with American ore loading and unloading devices at both terminals. They are the nearest approach to Great Lakes bulk freighters away from the Lakes themselves. They can also be used in the coal trade, and are without rivals anywhere on the seven seas for speed and efficiency of handling bulk cargoes.

The Lumber Trade "Steam Schooners" (A 5)

Panama Canal returns for one particular month show that approximately 218,260 tons of lumber were carried from the Pacific Coast to the Atlantic Coast. Most of this came from the Puget Sound and Columbia River districts from which much pine and redwood is exported not only to the Atlantic Coast, to South America, and to Chinese and Japanese ports, but also to other ports on the Pacific seaboard. Much of this export was, and some still is, carried out in wooden fore and aft schooners, built cheaply and easily on the spot. The demand for speedy transportation, however, and the adherence to schedule which mechanical power admits of has gradually put the sailing vessel out of business, just as the demand for economy is tending to replace the steamer with the motorship. Auxiliary power in the shape of the surface ignition engine and even of the steam engine has preserved many sailing schooners in the lumber trade and to a greater extent, perhaps, in the fishing and freight trades to far Alaskan and Arctic ports. Due chiefly to the fact, however, that the steam

engine was fitted to a number of sailing schooners as auxiliary power, the term "steam schooner" has come to be handed down to the present day ship engaged in the coastwise lumber trade. These ships vary of course in detail, but in general they are very similar to a type of ship known in British waters as the "Coaster." * They are strong, seaworthy craft with ma-



Much lumber export is still carried out in wooden fore and aft schooners.

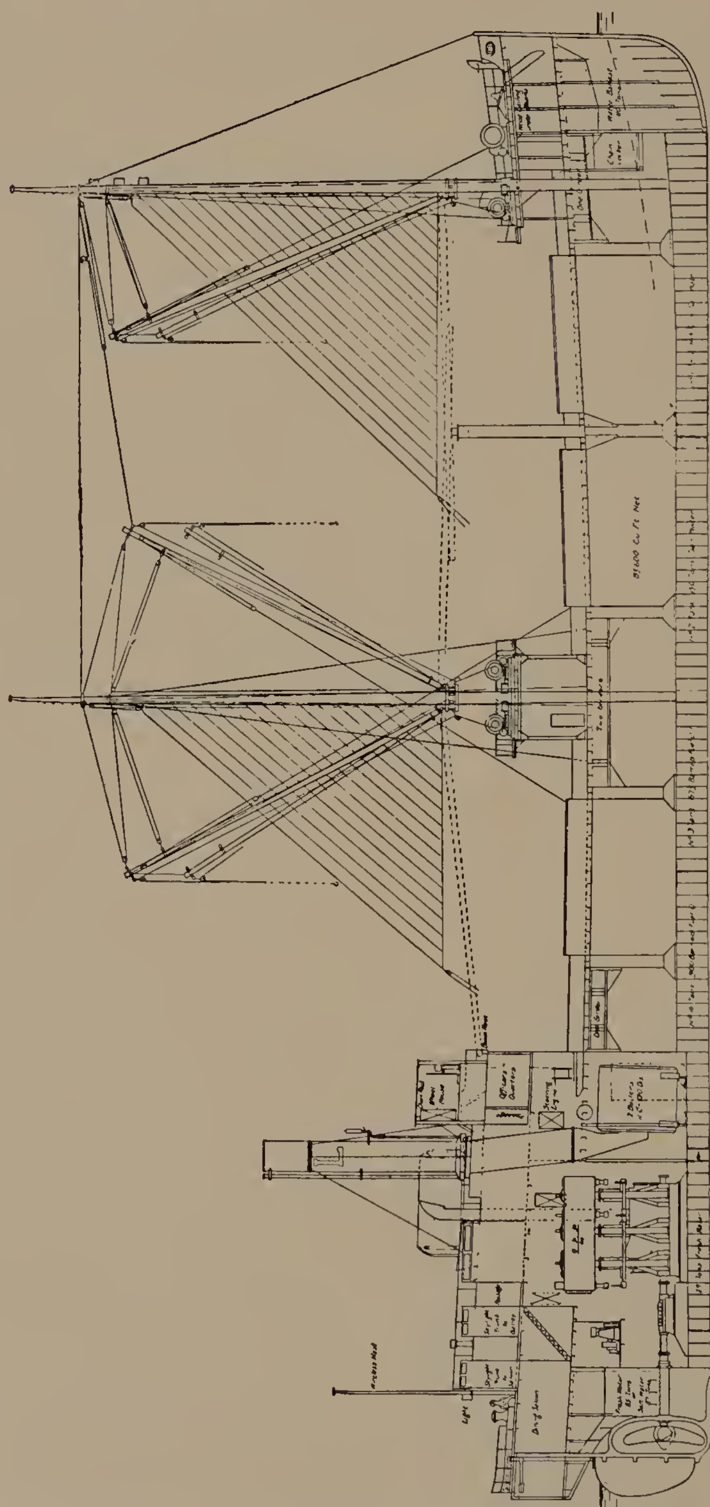
chinery aft. Deck and engineer officers' quarters are fitted in a moderately long poop as well as the navigating bridge which is usually arranged on the top of an engine casing at the fore end of the poop. The hold is clear from fore peak to forward machinery space bulkhead and the deck, which is one of the most heavily loaded parts of the hull structure with a full cargo of lumber on board, is supported by heavily built pillars and interconnecting centerline girders, continuous except in way of the hatches. The side coaming to the hatches are specially strengthened and are continuous from the break of the forecastle to the poop, thus forming strong fore and aft deck girders. This practice is generally adopted in smaller type colliers. A deep double bottom also contributes to longitudinal strength and provides immersion for the screw when the ship is light because it is fitted for carrying ballast water. It is important that the steam schooner should be able to handle her cargo quickly and efficiently

* See also "Merchant Ship Types." (Van Nostrand Co.)

and hence she has a very complete winch and derrick equipment which will enable her to pick up logs from the water and load them on deck or to load and unload planks from a dock side. Two or three masts are fitted, one at the break of the forecastle, one in the center of an otherwise clear deck space and, in some cases, the third mast on the poop. The winches are either on the forecastle or on a small housetop amidships or on the poop — all clear of the cargo. This is a point which designers of ships for the North Sea (Scandinavian-Great Britain) timber [1] trade would do well to note as their deck loads invariably cover up their winches. Designers both of the steam schooners and of British coasters can with advantage pay attention to the advantages accruing from the replacement of obsolete wooden hatch covers by modern steel covers of which there are several makes on the market. These obviate the danger of loosing a ship in ballast owing to a heavy head sea breaking open the wooden hatch covers and flooding the hold, causing a trim by the head.

It has been mentioned that there is a similarity between steam schooners and British coasters. This remark was inserted principally because a number of such vessels have been brought out to the Pacific coast for service in the Canadian lumber and coastwise trade from Vancouver, B. C. and similar ports. The reason is that the coasters can be bought cheaply second-hand in Great Britain, brought out to their destination with a cargo and adapted easily to their new work. This consists mainly of removing the bridge structure from midships — the usual place in a coaster — aft to the poop, lengthening the masts and adding extra derricks, none of which operations affect the geometrical properties of the ship to any great extent. Vessels specially designed for lumber work have large freeboard, a slightly higher beam-length ratio than other ships. As has been shown, the hulls are very strong. Steam reciprocating engines and oil burning boilers have formed the propelling power for a number of these schooners but the su-

[1] Note that the term "timber" is used as contrasted with lumber. These European cargoes comprise comparatively short sawn planks and circular pit props imported as an exchange cargo with coal.



Inboard profile of a typical lumber schooner of $1\frac{1}{2}$ million ft. lumber capacity, as illustrated in Johnson's "Measurement of Vessels for the Panama Canal." Fleets of ships of this kind operate on the Pacific Northwest Coast.

perior merits of the Diesel engine and of the surface ignition oil engine are steadily being realized. Their virtues of low operating costs, low fuel consumption and absence of standby and lay over losses are specially valuable to ships engaged in this type of trade. The above remarks have described the orthodox "schooner." There are of course many variations from and adaptations of this design in service. Some ships have their engines amidships and accommodation for a few passengers, for example. In any case a three island design (i.e., poop, bridge and forecastle) is adopted for obvious reasons, the two wells making excellent resting places for the logs or planks, as the illustration in Chapter one shows. A typical steam schooner has characteristics as follows:

Characteristics of a Steam Lumber Schooner

Length b.p.	235 ft. 0 in.
Beam, molded	42 ft. 6 in.
Depth, molded	18 ft. 8 in.
Gross Tonnage (U. S. Register)	1600 tons
Net Tonnage	915 tons
Cargo Capacity	1,500,000 ft. lumber

East Coast Passenger and Freight Ships (A 2)

Combination passenger and freight ships link New York and Boston with Charleston, S. C., Savannah, Jacksonville, and other southern ports. Boston is also connected during the summer season with the Maine Coast ports by passenger and freight ships whose characteristics are 50 per cent Bay steamer and 50 per cent Coastwise steamer. These are among the border line cases referred to in the introduction. The first mentioned services have produced a definite group, which we can label the East Coast type. Ships designed within the last few years for this work are a very great improvement on their predecessors, but some of the older East Coast ships are by no means the finest products of naval architectural skill, being rather in some cases an undesirable reflection upon the progressive spirit usually manifest in this country. Here are the reasons for this criticism:

Lack of appreciation of the value of speed, few if any of the older East Coast ships having a speed greater than 15 knots.

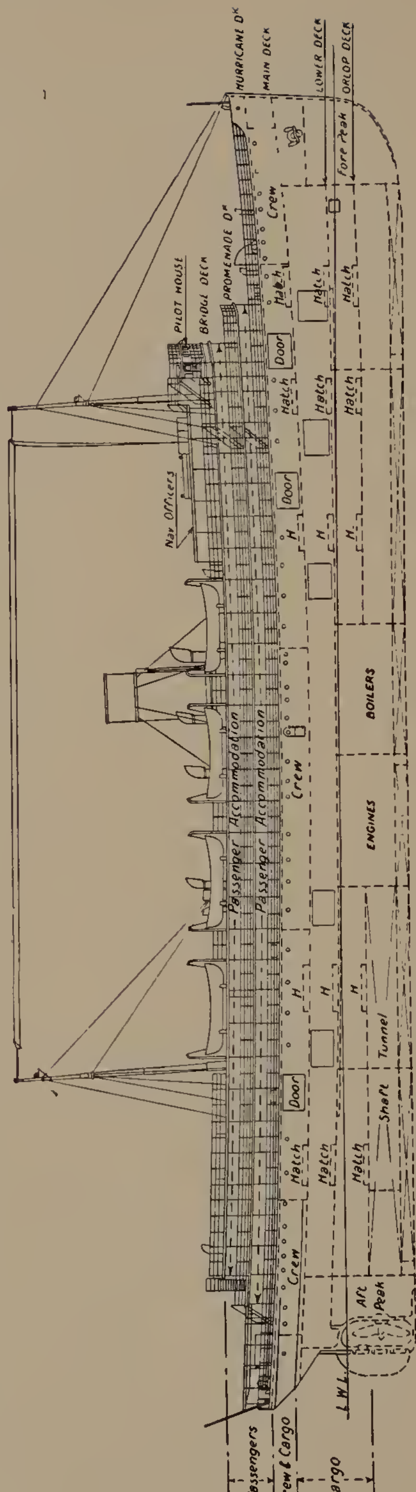
Lack of good, up-to-date accommodation which attracts the travelling public and helps to pay for the difference in speed between 15 and 21 knots.

The obsolete custom, still adhered to by many companies, of charging a fare for transportation only, to which a sur-charge must be added if a berth is occupied. To charge an inclusive fare for transportation and berth is really the same in the end, but it produces a better effect upon the travelling public.

Slowness in adopting the Diesel engine for propulsion with its superior economy of operation over a steam plant and absence of standby losses — an important point in these ships which spend a considerable proportion of their working year in port loading and unloading with fires banked.

An idea of the characteristics of some recent ships is obtained from the table.

As offsets to these criticisms must be mentioned the excellence of the general arrangement whereby considerable amounts of cargo are carried without the hatchways or cargo handling arrangements in any way obtruding themselves upon the



Inboard profile of East Coast Type Hurricane Deck Passenger and Freight Ship.

Details of Typical Eastern Coastwise Passenger and Freight Ships

Reg'd Dimens			Tonnages			Pass		Cargo Capacity (cu. ft.)	Machinery
L	B	D	Draft	G	Disp	1st	2nd		
350	52	36	19	5486	6930	285	30	26,900	1 Recip Steam
387.5	54	31.5	18	5300	7160	369	80 steerage	172,500	Geared Turbines 1 set
350	52	35	19	5486	6950	205	24	307,319 bale	1 Recip Steam

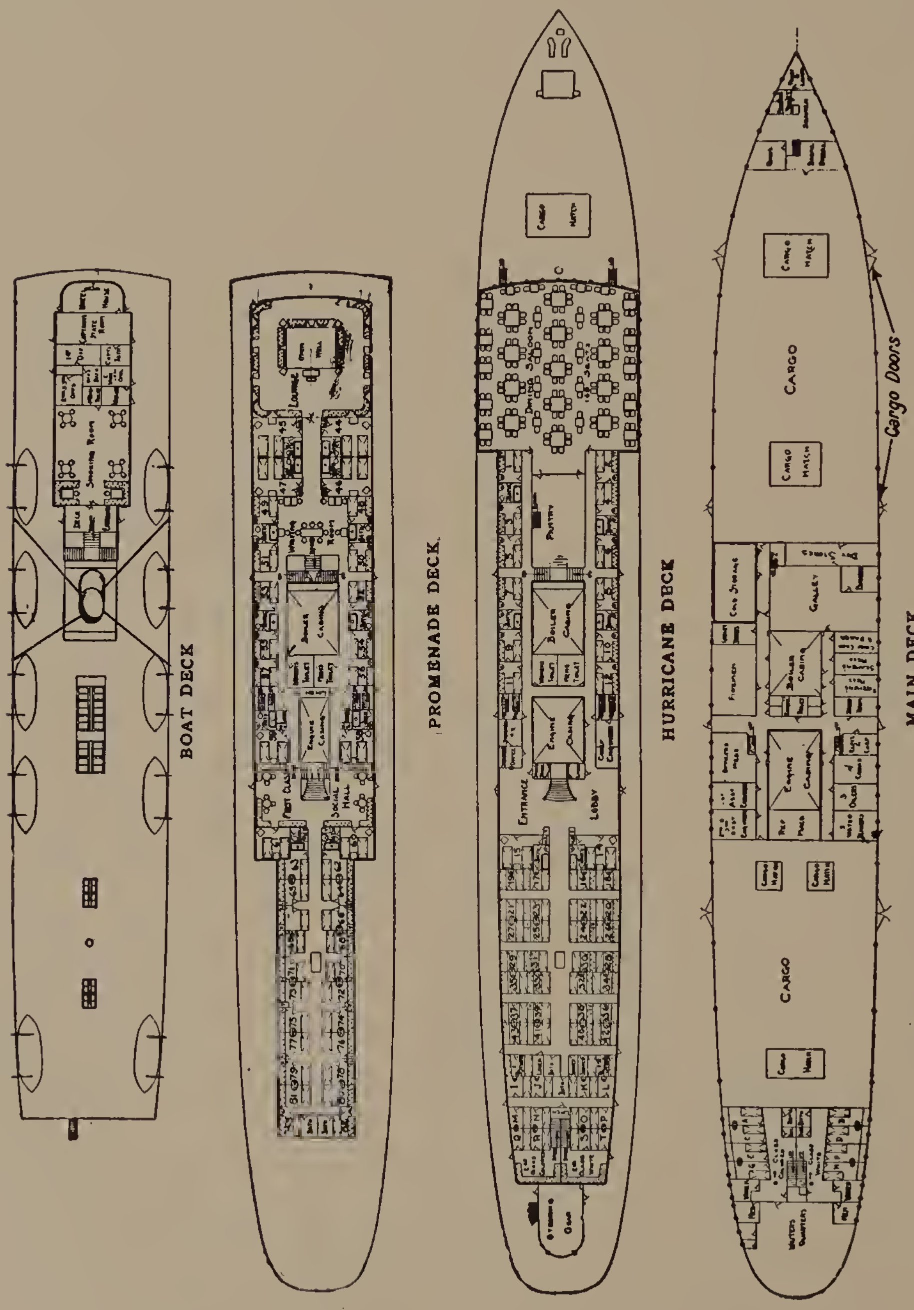
Power	Sea Speed	Service	No. of Decks	Structural Type	Bulkheads (W. T.)
2700 i.hp. 81 r.p.m.	12	Philadelphia Savannah Jacksonville	4 steel* 2 wood	Hurricane Deck	2 to Main Deck 4 to Upper "
4200 s.hp.	15	New York Charleston Jacksonville	—	Hurricane Deck	—
2700 i.hp.	12	Baltimore Savannah Jacksonville	4 steel* 2 wood	Hurricane Deck	2 to Main Deck 4 to Lower "

* 3 continuous, 1 discontinuous in way of machinery.

passengers. The arrangement at the same time permits of the passenger accommodations being carried all fore and aft without the sacrifice of any space to wells and hatchways. It is an arrangement which could well be investigated and adopted by the designers of fast cross channel ships operating on night services between Great Britain and France where much valuable deck space is taken up by hatchways and trunks.

Coastwise ships running on the East Coast are in general of Hurricane Deck type, the hurricane deck being the topmost

continuous deck, running all fore and aft and corresponding in ocean-going parlance to a shelter deck. Below this there are two tiers of 'tween decks running fore and aft and one deck which is worked only forward and aft of the machinery space. All cargo



Arrangements of passenger accommodations and freight space on an East Coast Ship.

is taken care of in these 'tween deck spaces, unloading and loading being carried out through side doors in the ship's sides suitably spaced in relation to the hatchways.

Elevators are used in some ships in the place of winches and tackle and the cargo — general cargo, vegetables, tobacco, etc. — is usually of such a nature that it can be transported easily from the furthest recesses of the 'tween deck spaces or holds to the hatches or elevators. No cargo ever goes higher than the topmost 'tween deck space — called the main 'tween decks — and it is then unloaded through the side doors. The passenger is thus unaware that any cargo is on board the ship at all and it permits a clean run of passenger decks to the stern. Passenger accommodation on a hurricane deck ship is concentrated on two or three decks above the hurricane deck from about 30 ft. abaft the stem bar to the stern. The 30 ft. space serves a sort of forecastle and in some ships is separated from the passenger decks by a short well containing a hatchway. In this case, of course, the hurricane deck is not continuous. The hurricane deck itself is entirely clear for passenger accommodation, with the exception of a comparatively small space for the engine and boiler casing, the accommodation being arranged in a long house about two thirds of the deck in width and slightly wider in way of the machinery casings. In modern coastwise ships, the dining saloon is located on this deck either forward or aft of amidships. When arranged at the extreme forward end of the superstructure, it has the advantage of clear windows for observation also. Entrance lobby, lounge, and smoking saloon are other important spaces in the accommodation, arranged according to the fancy of the designer on the promenade or hurricane decks. Navigating officers' quarters and the wheelhouse are on the bridge deck, the wheelhouse having a rounded forward end and the bridge itself extending no further than the width of the house top. It thus differs from the "ocean-going" bridge in having no wings with sidehouses stretching to the ship's side. There are a few exceptions to this rule, some designers for example preferring an ordinary oblong teak charthouse. In fact there is a distinct tendency in the more modern ships towards

the fitting of an ordinary type of bridge structure. The old pilot house is disappearing. Details of the deck arrangements of a typical East Coast ship are shown in the foregoing plan views.

Structurally, the Isherwood longitudinal system of construction has found some favor with designers, although the ordinary transverse system of construction is still used in a great many ships. Double bottoms are fitted all fore and aft. Sometimes two rows of channel bar section pillars are fitted, one on either side of the centerline and sometimes there is a single row of built pillars on the centerline, depending on the size of the ship.

Running Times of Coastwise Ships

In conclusion, it is of interest to mention something of the powering of these East Coast ships and of the schedules to which they operate. The table shows that a speed of from 12 to 15 knots is maintained, this being given either by turbines or by steam reciprocating engines. Power varies from 2700 i.hp. in the case of reciprocating engined ships to 4200 s.hp. with the turbine ship. The time taken to perform the various runs is long considering the distances. It is consistent with the service requirements certainly, but very little attempt is made to attract passengers by speed. Speed would pay for itself very quickly by added traffic, and speed is the only thing to draw new business in large quantities. In 1926 one particular eastern seaboard company advertised 80 hours from Philadelphia to Miami with a sailing once every 10 days. In the winter season of 1925–26, *H. F. Alexander* temporarily diverted from the Pacific Coast, ran from New York to Miami in 48 hours, leaving New York every fifth day. The Florida "boom" was largely responsible for the demand for this type of service, but even so it was an indication of what could be done in coastwise transportation. *H. F. Alexander* is labeled by her owners "the largest, fastest, and most luxurious coastwise liner in the world." She certainly is a successful competitor of the railroads.

Following is a table showing the schedule ordinarily adhered to

by typical ships engaged in the coastwise passenger and freight trade, compiled from data issued to the public by the companies in question. It is of particular interest to note the time taken from point to point on the coast.

ROUND TRIP NEW YORK TO NORFOLK, VIRGINIA
(Old Dominion Line)

OUTWARD

Position	Miles	Time
Lv. New York	—	12 00 noon
Pass Battery	2	12 12 pm
" Narrows	9	12 36 pm
" Romer Light	16	12 57 pm
" Sandy Hook	18	1 05 pm
" Ambrose Channel (outer entrance)	20	1 11 pm
" Scotland L. Ship	23	1 24 pm
" Highlands	27	1 36 pm
" Long Branch	33	1 58 pm
" Asbury Park	39	2 16 pm
" Belmar	41	2 24 pm
" Sea Girt	46	2 39 pm
" Barnegat	72	4 07 pm
" Little Egg Harbor	94	5 22 pm
" Brigantine Buoy	100	5 41 pm
" Absecon (Atlantic City)	105	6 01 pm
" N. E. End L. Ship	132	7 33 pm
" Delaware L. Ship	145	8 17 pm
" Five Fathom Bank	145	8 17 pm
" Fenwick Is. L. Ship	170	9 41 pm
" Winter Qr. L. Ship	207	11 47 pm
" Chincoteague	225	12 46 am
" Hog Island	262	2 52 am
" Cape Chas L. Ship	280	3 51 am
" Smith's Is.	286	4 14 am
" Cape Henry	299	4 58 am
" Tail of Horseshoe	302	5 06 am
" Thimbles	313	5 44 am
Pass Old Point	316	6 00 am
Ar. Norfolk	328	7 30 am

Total Dist. 328 m. Total Time 19 hrs. 30 min. ∴ Avg. Speed 17 m.p.h.

HOMEWARD

Position	Miles	Time
Lv. Norfolk	—	7 15 pm
Pass Old Point	12	8 00 pm
" Thimbles	15	8 13 pm
" Tail of Horseshoe	26	8 53 pm
" Cape Henry	29	9 03 pm
" Smith's Is. Buoy	42	9 48 pm
" Cape Chas. L. Ship	48	10 13 pm
" Hog Island	66	11 16 pm
" Chincoteague	103	1 31 am
" Winter Qr. L. Ship	121	2 35 am
" Fenwick Is. L. Ship	158	4 49 am
" Five Fathom Bank	183	6 19 am
" Delaware L. Ship	183	6 19 am
" N. E. End L. Ship	196	7 06 am
" Absecon (Atlantic City)	223	8 42 am
" Brigantine Buoy	228	9 03 am
" Little Egg Harbor	234	9 23 am
" Barnegat	256	10 42 am
" Sea Girt (Stockton H'se)	282	12 17 pm
" Belmar	287	12 33 pm
" Asbury Park	289	12 41 pm
" Long Branch	295	1 01 pm
" Highlands	301	1 24 pm
" Scotland L. Ship	305	1 37 pm
" Ambrose Channel (outer entrance)	308	1 51 pm
" Sandy Hook	310	1 58 pm
" Romer Light	312	2 06 pm
" Narrows	319	2 27 pm
" Battery	326	2 50 pm
Ar. New York	328	3 00 pm

Total Dist. 328 m. Total Time 19 hrs. 45 min. ∴ Avg. Speed 16.6 m.p.h.

Ex-coastwise freighter converted to powerful Diesel-electric dredge.

Round Trip New York to New Orleans, La.
(*Southern Pacific Line*)

Outward	Day	Time	Dist. from New York Miles	Miles off Shore
Leave New York, Pier 48, North River........	Sat.	12 noon		
Off Scotland Lightship......................	"	2 00 pm	23	3
" Barnegat Light........................	"	5 00 pm	70	8
" Absecon Light.........................	"	7 30 pm	102	15
" Cape May, N. J........................	"	9 35 pm	133	30
" Five Fathom Bank Lightship............	"	10 15 pm	145	30
" Norfolk, Va...........................	Sun.	7 00 am	281	56
" Diamond Shoal Lightship (off Hatteras)....	"	2 15 pm	403	14
" Charleston, S. C......................	Mon.	2 00 am	565	175
" Savannah, Ga..........................	"	6 20 am	618	195
" Brunswick, Ga.........................	"	11 30 am	690	192
" Jacksonville, Fla.....................	"	2 25 pm	752	170
" St. Augustine, Fla....................	"	4 30 pm	792	152
" Jupiter Light, Fla....................	Tues.	11 50 am	1038	4
" Palm Beach, Fla.......................	"	1 00 pm	1054	1
" Hillsboro Light, Fla..................	"	4 30 pm	1087	1
" Miami, Fla............................	"	7 40 pm	1120	3
" Fowey Rocks Light, Fla................	"	8 25 pm	1133	1
" Carysfort Reef Light, Fla.............	"	10 25 pm	1160	1
" Alligator Reef Light, Fla.............	Wed.	1 10 am	1198	1
" Sombrero Reef Light, Fla..............	"	3 25 am	1234	1
" American Shoal Light, Fla.............	"	5 30 am	1261	1
" Sand Key Light, Fla...................	"	7 00 am	1285	1
" Tortugas Light, Fla...................	"	12 noon	1359	10
Pass South Pass, La., mouth of Miss. River....	Thur.	8 00 pm	1847	....
Arrive New Orleans head of St. Louis Street....	Fri.	7 00 am	1958	....

Total Dist. 1958 m. Total Time 139 hrs. 0 min. ∴ Avg. Speed = 14 m.p.h.

Homeward (*with Gulf Stream*)	Day	Time	Dist. from New Orleans Miles	Miles off Shore
Leave New Orleans, head of St. Ann Street.....	Wed.	10 00 am		
Pass South Pass, La., mouth of Miss. River....	"	5 00 pm	110	
" Tortugas Light, Fla...................	Thur.	11 00 pm	597	10
" Sand Key Light, Fla...................	Fri.	3 36 am	673	6
" American Shoal Light, Fla.............	"	5 06 am	698	6
" Sombrero Reef Light, Fla..............	"	6 53 am	726	6
" Alligator Reef Light, Fla.............	"	9 00 am	763	7
" Carysfort Reef Light, Fla.............	"	11 18 am	803	7
" Fowey Rocks Light, Fla................	"	12 40 pm	832	7
" Miami, Fla............................	"	1 22 pm	846	8
" Hillsboro Light, Fla..................	"	3 01 pm	881	8
" Palm Beach, Fla.......................	"	4 40 pm	913	9
" Jupiter Light, Fla....................	"	5 30 pm	929	12
" St. Augustine, Fla....................	Sat.	4 18 am	1134	90
" Jacksonville, Fla.....................	"	5 50 am	1164	96
" Brunswick, Ga.........................	"	8 36 am	1214	105
" Savannah, Ga..........................	"	9 58 am	1240	110
" Charleston, S. C......................	"	12 36 pm	1282	95
" Diamond Shoal Lightship (off Hatteras)...	Sun.	5 30 am	1575	14
" Norfolk, Va...........................	"	1 30 pm	1701	95
" Five Fathom Bank Lightship............	"	9 30 pm	1832	32
" Cape May, N. J........................	"	10 05 pm	1842	30
" Absecon Light.........................	Mon.	12 07 am	1875	11
" Barnegat Light........................	"	2 05 am	1907	8
" Scotland Lightship....................	"	5 05 am	1954	3
Arrive New York, Pier No. 49, North River....	"	7 00 am	1977	....

Total Dist. 1977 m. Total Time 117 hrs. 6 min. ∴ Avg. Speed = 16.8 m.p.h.

[1] With a longer distance to run, a quicker homeward passage is made with the assistance of the Gulf Stream.

U. S. Bay and Sound Shipping

Related to Coastwise Shipping Retains Individual Characteristics

SHIPS coming within the bay and sound category occupy positions of importance varying in degree according to the geographical situation of the waterways on which they operate. Certain ships, for example, working the Inside Passage Route from Seattle to Skagway run only during certain times of the year. Winter weather conditions limit the all year round activities of ships operating between New York and Boston via the Cape Cod Canal. On the other hand, Long Island, acting as a protective wall to the Sound, permits an all year round service between New York and Providence and Fall River points. An all year round service is always maintained from Baltimore to Chesapeake and York River points, routes which can successfully operate against the railroads, because the main lines of these latter, are forced inland by the configuration of the Chesapeake Bay.

As with coastwise ships, so with Bay and Sound ships — the East Coast differs from the West Coast. Moreover this chapter really embraces one broad group of ships, members of which may navigate bays, sounds, and rivers in the course of their daily schedule, as well as any of these three separately. In the summer tourist season, small coastwise ships of size comparable with the Chesapeake Bay ships operate on the Maine Coast as well as from New York to Boston via the Cape Cod Canal. It has been pointed out in a previous chapter that the bays and sounds of this continent tended to group themselves, and with these groups come differences in the characteristics of the ships navigating them. Thus, on the Eastern seaboard, Long Island Sound, the Delaware and Chesapeake Estuaries form one group, while on the

Western seaboard there is San Francisco Bay with San Pablo and Suisun Bay and the Sacramento and San Joaquin Deltas forming one big group, and Juan de Fuca Strait with Puget Sound and the Inside Passage making a second group. Some Sound ships are designed for night work only on all year round service with passengers, mails, and freight; others operate on day and night services, i.e., part of the journey is performed by day and part by night, while others are designed to transport freight only, small oil tankers having become prominent of recent years in this latter class.

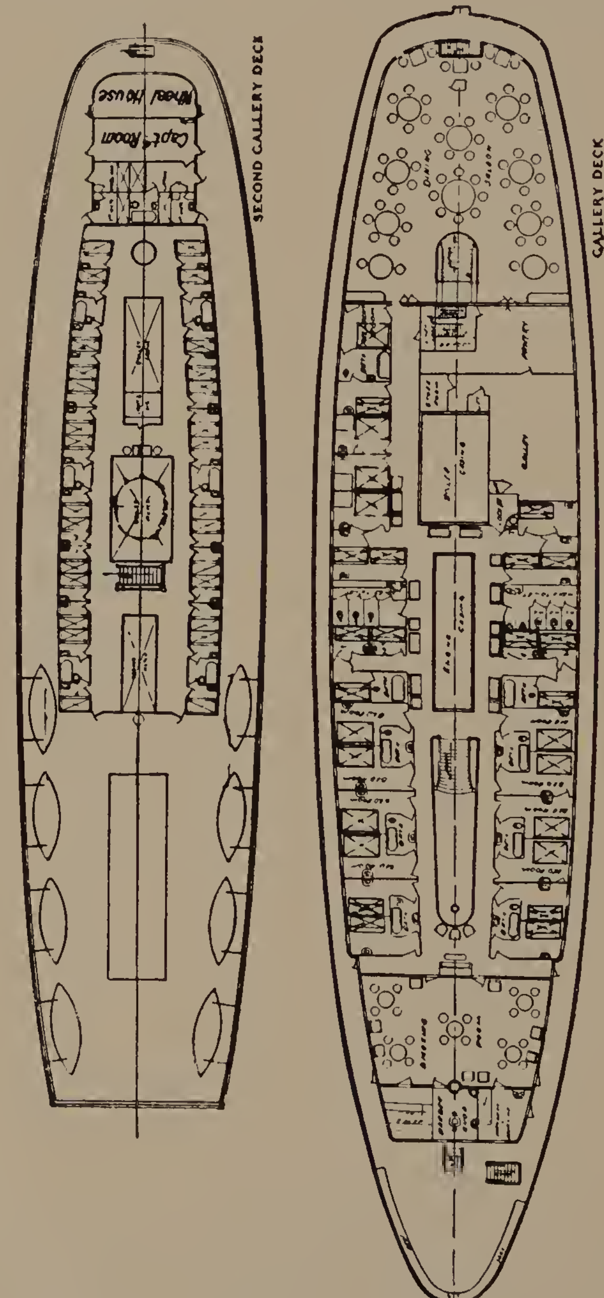
In speaking of Sound ships designed purely for night work, carrying mainly passengers and small quantities of freight, mention must also be made of the vessels of the Hudson River Night Line operating between New York and Albany on the Hudson River, the distance being covered in just 12 hours. No special attempts are made at record breaking speeds, the object being rather to permit of passengers leaving and arriving at their terminal points at a reasonable hour. The four ships usually running on this route although technically river craft are actually modified Sound ships, and their prototypes will also be found operating between various points on the Great Lakes where there is sufficient traffic to make a fast passenger and automobile carrying service a paying proposition, and one which can compete successfully against the railroads. Here again, as with the coastwise services, it is a case of definitely schooling the public to appreciate the advantages of fast comfortable night travel by water. This cannot be done successfully either by obsolete ships or by indifferent accommodations. Where short night sea runs are necessary and where there is no possible railroad rivalry or even competition from another steamship route the public has sometimes been the victim of obsolescence mentioned, and it has been unable except by popular agitation to combat the evil. A case in point occurred recently on a British cross channel route in which popular agitation forced a railroad company to place in service two vessels of modern type and arrangement and to modernize the rest of its fleet. On Sound services where the ship is in direct

competition with the railroad, the ship goes out of service unless it keeps up-to-date, always excluding of course routes on which some seasonal tourist attraction exists.

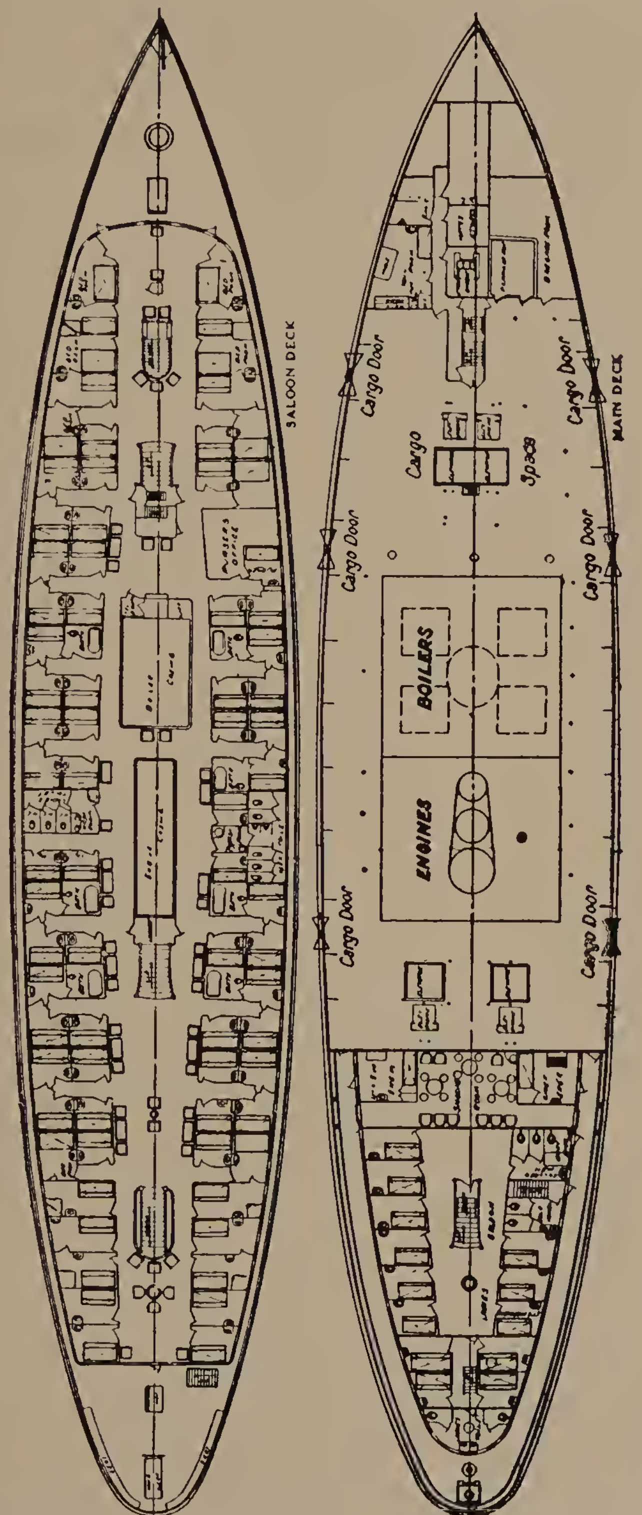
The East Coast Sound Ship

The East Coast Sound Ship must combine sleeping, washing and eating accommodations for at least 300 people on a length of hull overall usually not exceeding 300 ft. with about 50 to 60 ft. beam and a draft of from 12 to 14 ft. While the depth of hull is more or less fixed, the total depth is a variable quantity, as will be seen. There must be, in addition, space for a certain amount of freight of general nature including passengers' automobiles, as well as stores, fuel and fresh water. The design adopted has been evolved as a result of the experience of many years and generally speaking is uniformly successful. The general arrangement bears a very definite relation to that of the coastwise steamers which have been discussed in the previous chapter while the requirements are very similar to those for ships engaged in night runs between British ports and the continent of Europe, from Harwich in England to Antwerp in Belgium, for example. This similarity of service requirements is sufficiently illuminating to bring out the principal design features of the Sound-steamer. The distance from Harwich to Antwerp is 135 sea miles and the time taken is from nine to ten hours about three hours of which are taken up by navigating the Scheldt River from Flushing at the mouth, where the pilot is picked up, to the Quai d'Herbouville at Antwerp. Accommodation is provided for 370 passengers in a hull 337 ft. in length overall, 43 ft. beam molded and 26 ft. 6 in. depth molded. The draft is 15 ft. The ship is of two deck type with one superstructure deck extending about two thirds of the length of the ship from the bow; in effect an extended forecastle. Accommodation is all arranged *within* the hull and on the one superstructure deck towards the forward and aft ends of the ships. Many of the cabins on the lower deck are too near the waterline ever to permit of the ports being open, while those on the upper deck can only remain open

in fine weather. The accommodation is uniformly good, but cramped, and the problem of ventilating the lower decks successfully is no easy one. In the early morning when the ship arrives at her destination the atmosphere in this part of the ship is by no



Sound Ship Deck Arrangement



Deck arrangement of a typical East Coast Sound Ship in which main Dk. is strength deck, with three superstructure decks.

means 100 per cent pure. The ship is designed to make 21 knots and a considerable proportion of the midship portion of the hull — the most comfortable from the passenger point of view is taken up by machinery. Trunked cargo hatches run up to the top deck through the forward passenger spaces.

The distance from Baltimore to Norfolk is 187 miles and the time taken is 12½ hours, an average speed of nearly 15 miles per hour. Accommodation is provided for about 350 passengers in a hull about 330 ft. in length overall, 58 ft. beam molded, and 19 ft. depth molded. The draft is 12 ft. The ship has five decks; viz., the lower, main, saloon, gallery, and upper gallery or promenade deck. Of these, the main deck is the topmost strength deck of the hull and carries the remaining three decks as lighter superstructure. The main deck has the dining saloon and social hall at its aft end, the rest being devoted to freight space (two large cargo doors being arranged one on either side amidships) machinery casings and crew accommodation. The saloon and gallery decks are entirely devoted to passenger accommodations carrying 152 and 128 respectively. The gallery deck has a palm room at its aft end, while the promenade deck contains the pilot house and the navigating officers' quarters at the fore end and life boat equipment at the aft end; there is also accommodation for 52 passengers. The lower deck contains crew's quarters and stores as well as a certain amount of auxiliary machinery.

The important point of contrast, however, between the British and American designs is that in the latter all the passenger accommodation is above the waterline and all passenger rooms except 17 are outside rooms, many of them with private bathrooms attached and some with double beds. The equipment is further finished off with a barber's shop, a news stand, a clothes pressing and shoe shine service — refinements inseparable from American travel, even though it be overnight only, but unheard of in any European ship. All rooms for passengers are arranged towards the outside of the ship and large wide passages and galleries are thus possible inside. The engine and boiler casings are carried up to the promenade deck. Headroom is not restricted and hence in considering

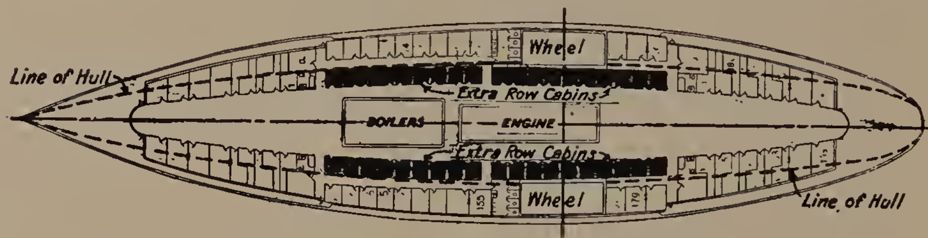
the employment of internal combustion engines for such ships the old bogey of excessive height, so often advanced in the case of the British cross channel vessel, is hardly applicable. The proportions of dimensions are naturally different in the two ships as would be expected. The Sound ship has a *maximum* depth of about 50 feet as compared with the cross channel ships 34 ft. maximum depth. The former's beam molded, however, is in consequence 58 ft. compared with the latter's 43 ft. The overall lengths are 330 ft. for the Sound ship and 337 ft. for the cross channel ship. All superstructure for the Sound ship is of light construction and is built upon a special midship section with flared side — used incidentally upon ships navigating the Chinese Rivers — which gives ample deck space and at the same time keeps a reasonable width on the waterline.

These details go to form the keynote to Sound ship design and may be studied in conjunction with the diagrams. Its advantages over the cross channel design are many but in defense of the latter it must be argued that the weather conditions in the North Sea are infinitely worse than those of the Chesapeake Bay.

An Extra Row of Cabins

The above represents the more or less standard arrangement for Sound ships. From the owner's point of view probably the principal improvement which could be effected is an increase in passenger capacity. There are two ways of doing this — by a deliberate increase in beam or by the use of side or paddle wheels for propulsion which gives a virtual increase in beam if the paddle sponsons are carried forward and aft and faired into the deck lines on each deck. Then the usual line of outside cabins can be arranged but there is, in addition, space for another row of cabins, usually small, on the inside of the outside cabins and between the latter and the machinery casings. This can be done without any real crowding, as the illustrations show, and is also a very general practice in the large sidewheel passenger packets on the Great Lakes.

Increase of beam and the adoption of a very flared midship section have permitted of this arrangement in *Boston* and *New York*, two of the finest Sound Steamers ever constructed, operated by Eastern Steamship Lines Inc., between New York and Boston via Cape Cod Canal during the summer season. In this case, however, the extra row of small rooms has been arranged on the outside of the main cabin superstructure although incorporated in the ship's hull because their outside walls are included in the



Shows how side wheels permit of an extra row of cabins in passenger packets.

strakes of shell plating. These two ships have three passenger decks above the main strength hull incorporated in what is virtually a superstructure hull which, forward, extends two decks vertically above the main deck and midships three decks above the main deck. The very pronounced midship flare is extended from stem to stern and the hull is all entrance and run with no parallel middle body. Some very fine problems in frame turning must have arisen from their construction.

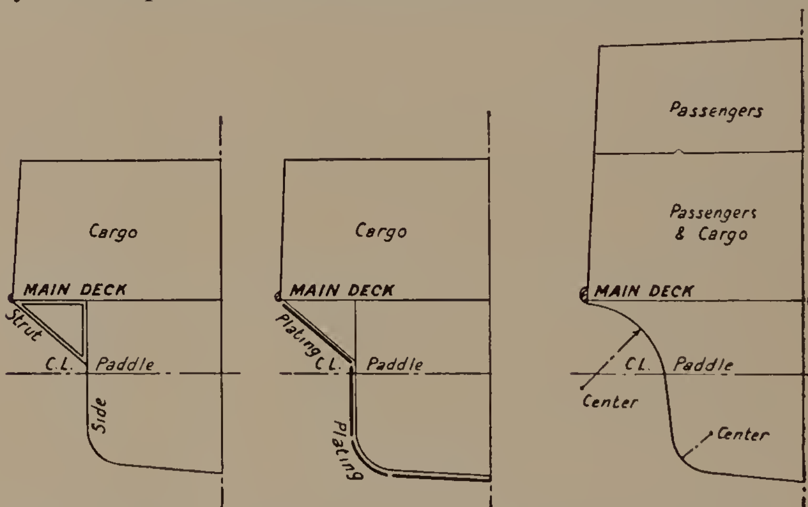
The illustrations of accommodation layout make clear the difference in arrangement between the coastwise ship, the screw Sound ship, and the paddle Sound steamers. At the same time it is possible to trace a distinct family likeness throughout. The following figures make clear the arrangement adopted for decks and rows of cabins.

	Normal Sound Ship	*'Boston' 'New York'*	*Paddle Packet*
Length	330 ft.	385.3 ft.	422 ft.
Beam	58 ft.	72.5 ft.	86 ft.
No. of Pass decks	3	3	3
No. of Rows of cabins on each side of centerline	1	2 on two decks amidships	2 on two lower decks

Ss. New York and Boston, owned by Eastern Steamship Lines Inc. are fine fast Sound ships embodying many novel design features.

The flared midship section besides being a very practical method of getting a good wide deck space without increasing the waterline width is probably a direct development from the sidewheeler. Take away the side wheels and you have a wide overhang deck. Support this with stays forming the third side of a triangle between the deck and ship's side as it is done in many screw ferry-boats. Plate this in, and later fair to a good hull shape in the mould loft floor, and you have at once the flared midship section, as the sketch indicates.

Construction details of the Sound ship follows those adopted in many fast ships of moderate dimensions and draft. The molded



Sketch showing the natural evolution stages of the flared midship section.

depth does not permit of the cellular type double bottom usual in ocean-going ships. Hence in some ships a frame and reverse frame or "Z" frame system and in others a simple angle bar system is worked in conjunction with a bar or side bar keel. Longitudinal keelsons are worked as intercostals to the floor plates being continued upwards between channel bars arranged back to back to form strong girders. A 1,943 ton displacement Sound ship with a length b.p. of just over 297 ft. has framing 6 in. x $3\frac{1}{2}$ in. x $3\frac{1}{2}$ x 15lb. "Z" frames to the main deck. There are two side keelsons and one longitudinal girder worked along the floors on either side of the centerline. These ships have consider-

able rise of floor, and instead of the "tumble home" usually associated with a midship section, there is a flare. In the case under consideration the rise of floor is 20 in. and the "flare" 4 ft. $3\frac{1}{2}$ in.

Sound Freighters

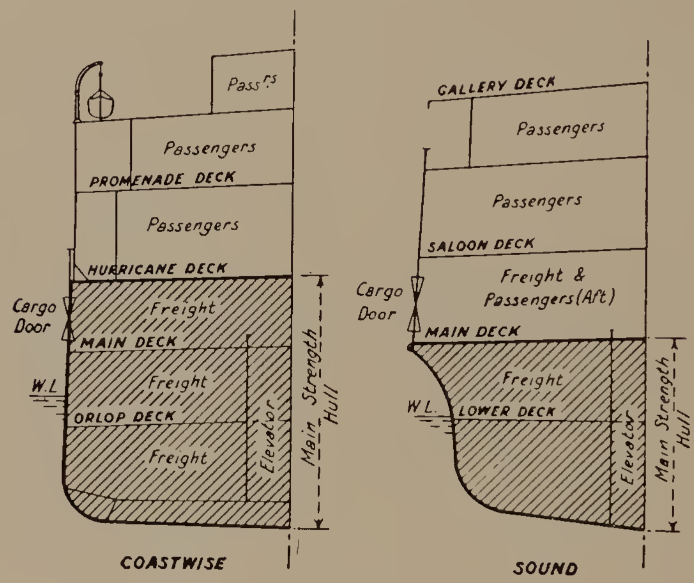
Most companies operating in the services outlined above maintain freight-only ships which are in effect nothing more nor less than duplicates of the passenger Sound ships with the top pas-

Puget Sound possesses a variety of craft engaged in passenger and freight service like the Reliance, shown above, which illustrates the "box idea."

senger decks omitted. Some are especially built for the work — notably the smaller type of which there are good examples in Puget Sound as will be seen — but many others are ex-passenger ships with the top decks cut off, which makes the saloon deck actually the hurricane deck. Some of these converted ships are 40 to 50 years old and even as late as 1926 it was possible to observe along side piers in New York harbor ships of 300 ft. length with old walking beam engines, operating with freight cargoes to ports and points on Long Island Sound. San Francisco Bay, Puget Sound and the Chesapeake area all have the same type of Sound cargo ship operating with various modifications in arrangement according to the district.

The Box Idea

The idea of carrying general package freight in clear superstructure spaces above the main strength deck, although it differs from arrangements usually adopted in ocean shipping where the hatchway is used, has much to recommend it. It is only package freight, of course, which can be handled in this way — bulk freight such as grain, coal and ore needs large wide hatches. Side doors permit of easy unloading and loading. Freight is kept away



The "box idea" is well shown in this sketch contrasting coastwise and Sound ships.

from the effects of the weather. The cargo spaces in some ways are comparable to boxes arranged on the strength hull and it is possible to trace a relationship, for this reason, pointing at the same fundamental idea between the sound freighter, the covered barge of the railroad company and the box barges evolved by the Inland Waterways Corporation for the Mississippi and Black Warrior Rivers.

The "box idea," as we may conveniently term it, is well illustrated in *Reliance*, a mixed passenger and freight ship operating on Puget Sound. Actual freeboard is a matter of 12 to 18 in. but above the main deck is a space about 8 ft. high with a dining

saloon and accommodation at the aft end and cargo space at the fore end. Above this box is another deck with a cabin superstructure and wheelhouse. Two stout masts with suitable struts attached to the decks contribute to longitudinal strength. It will be noticed that in this case some freight is carried on deck also. River ships employed in similar services on European waters — for example from Rotterdam to Nimigen on the Dutch-German frontier or between Glasgow and various points in the Western Highlands of Scotland — in which package freight has to be carried, in nearly every case use an open deck space at the forward end of the ship for the purpose.

Lack of deep water available for navigation both during the trip and at terminals is probably one of the principal reasons underlying the "box idea." Thus the cargo is carried *on* the hull rather than *in* the hull.

"Puget Sounders" (*B 2*)

Puget Sound, Juan de Fuca Strait and neighboring waters provide a somewhat different interpretation of the passenger carrying Sound ship — in arrangement a sort of hybrid between a coastwise and a Sound ship — and in speed something faster than the average Sound ship and faster than all but the most record-breaking coastwise ships. These ships have been evolved by the various railroad companies operating from British Columbian ports and are employed in fast passenger and mail services between points on the mainland and outlying islands, as well as between Puget Sound ports. They even work as far north as Skagway. Let us now examine these differences in greater detail. Many of these ships are designed and built in British shipyards by men accustomed to the British type of railway cross channel vessels, to which there is a certain resemblance, in one pair of sister vessels, in a trunked hatchway running up from the cargo space to the weather deck. Beam is less than in East Coast Sound ships because an ordinary and not a flared midship section is adopted. There is therefore on each passenger deck an appre-

A typical "Puget sounder," Canadian Pacific Ss. Princess Kathleen. Ship is part Sound ship and part cross channel type.

ciable length of what amounts to parallel middle body. The main strength deck of the ship is also the weather deck, i.e., the deck having a short forecastle at its forward end. In East Coast Sound ships the weather deck is invariably one above the strength deck, to which the lines are faired and above which they run in a vertical line. In this point the Puget Sounder is comparable with the Eastern Seaboard Coastwise Ship. She has invariably two complete decks — all fore and aft and termed shelter and main respectively, one superstructure deck — the shade deck, and a 'tween deck discontinuous in way of the machinery space. Scenic wonders on these waters render desirable the fitting of large observation rooms with semi-circular window spaces. These are conveniently arranged at the forward and aft ends of the superstructure. Second class accommodation, in some of these ships is forward — an arrangement not very common in passenger ships. Construction of hull follows usual Sound practice, limited draft making necessary the frame and reverse frame principle without double bottom in all but the largest ships.

Speed, higher than that of either Sound or Coastwise ships, varies from 18 to 22½ knots. Up to date practice in turbines and oil fired water tube boilers in more recent ships takes care of this. Though not universal, it is very general practice to fit three stacks to these ships and this in conjunction with a cruiser or graceful counter stern gives them a snappy and distinctive appearance. Though a high service speed is required, this may not be used throughout the entire trip, as exemplified by Canadian Pacific Railroad's day and night "triangle" service between Vancouver, Victoria, and Seattle. This is completed once in 24 hours, the total journey being about 300 miles. Ships leave Victoria at mid-day and return from Seattle or Vancouver the following morning, carrying day traffic on one portion of the route and night traffic on the other. Hence larger public rooms are provided than would be necessary for a ship engaged in night service only. On the other hand the night sleeping accommodations prohibit a perfect day arrangement. Provision is made in the topmost cargo 'tween deck space for the carriage of automobiles — a

factor of increasing importance on all American routes which the side loading methods suit admirably.

The night portion of the journey is carried out at 16 knots and the day portion at 22 knots. This difference in speed is taken care of in two recent ships by the provision of two water tube boilers in addition to six cylindrical boilers, the two water tube boilers supplying the extra steam to the turbines during the day.

Recent practice in fast West Coast Sound ships shows dimensions and characteristics as follow:

Puget Sound Ship Particulars

Regd. Dimensions L × B × D	Tonnage	Speed	No. of Decks	Remarks
350.1 × 60.1 × 17.1	5,875 G	22.5	4 (3 Pass)	1380 day pass.
300.0 × 46.0 × —	—	18	5 (3 Pass)	239 pass.
185 × 29.5 × 17.25	904 G	11½	1 Complete; 2 part	52 first; 200 steerage

This table has been purposely graded to show that the type under discussion varies in size. The last example is a case of a ship converted for the work. Originally a raised quarter deck steamer in the British coasting trade, of typical coaster arrangement[1] with engines aft, a short forecastle and a bridge house, the ship was reconstructed to fit her for her new work. This comprised the filling in of the well between bridge and forecastle, the construction of a deck, and the building of another deckhouse above this with accommodations for 52 first class passengers. The original engines and boilers were used and, as far as is known no attempt was made to increase the stability by fitting large wide fenders at waterline level. The ship was employed in mail and passenger service between Prince Rupert, B. C. and Queen Charlotte Islands.

Following are some schedules maintained by typical ships discussed in this section:

[1] See Lumber Schooners in the previous chapter.

Canadian Pacific Triangle Route

OUTWARD		HOMEWARD	
Vancouver Lv...10.30 am Victoria Ar...... 2.30 pm Victoria Lv..... 4.30 pm Seattle Ar...... 8.30	11.00 pm 7.45 am (Direct)	Seattle Lv. ... 9.00 am Victoria Ar....12.45 pm Victoria Lv.... 2.00 pm Vancouver Ar.. 6.00 pm	11.30 pm 7.00 am (Direct)

Canadian Pacific Alaska Route
(*Specimen schedule*)

OUTWARD		HOMEWARD	
Victoria Lv............	June 11	Skagway Lv...........	June 17
Vancouver Lv...........	June 12	Juneau Lv.............	June 18
Alert Bay Lv............	June 13	Wrangel Lv............	June 18
Prince Rupert Lv........	June 14	Ketchikan Lv..........	June 19
Ketchikan Lv...........	June 14	Prince Rupert Lv.......	June 19
Wrangel Lv.............	June 15	Alert Bay Lv...........	June 20
Juneau Lv..............	June 15	Vancouver Lv..........	June 21
Skagway Lv............	June 16	Victoria Ar.............	June 21
Round trip 11 days		Continues to Seattle same day	

It has often been argued that some of these railway owned ships operating in Western waters are superior in equipment and in operation to some of the Eastern seaboard ships. If this is so, it is for two reasons: in the first place there is a certain amount of competition between the owners concerned. Secondly the services are in some cases integral parts of a railroad journey and hence railroads can provide superior accommodations because they make a profit on any given journey on the complete length and not on one particular part — the sea part.

Day Services

Day services on Puget Sound are taken care of by ships of about 500 tons gross, similar to those shown in the illustration, operating between Seattle and Bremerton or Seattle and Tacoma. Such ships are of comparative light draft and have one deck and

a superstructure house forming a species of boat deck with its top above the main strength deck. A certain amount of freight can be loaded through side doors forward. Large dining saloons and roomy day cabins are arranged. Such a ship is 179.2 feet length b.p. by 28 feet beam molded by 11.3 feet depth molded to main deck. Steam reciprocating engines furnish 2000. i. hp.

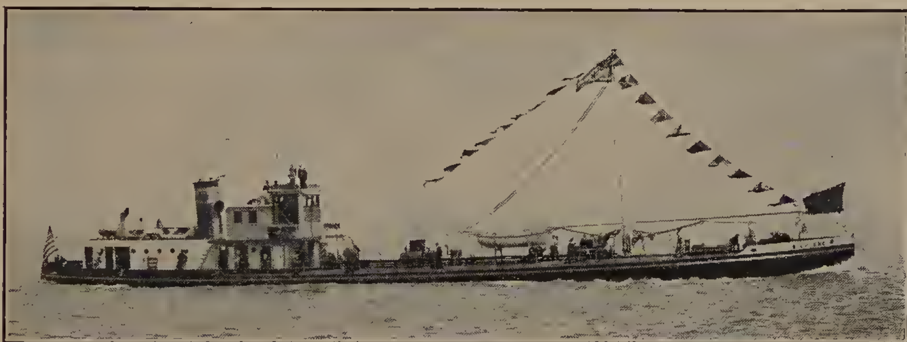
Ships of this kind operate fast day passenger schedules on Puget Sound.

for propulsion giving a speed of about 12–14 knots — just the ideal case for Diesel engines to cut out maintenance costs when tied up at night and to give more freight and passenger space.

San Francisco Bay (*B 4*)

San Francisco Bay and adjoining waters is the home of many ship types. Most numerous among recent ships built for service there are the shallow draft oil tankers which have made their appearance gradually since the demand for fuel oil and its distillates began to attain the importance it now has. This trade has developed a special type of small tanker, similar in many ways to the coastwise tankers we have already discussed but more limited in draft. These ships take the products of refineries on the Bay and transport them to outlying districts and to points on the deltas. A fore peak is followed by a cargo hold in which package freight is carried to various outlying stations. Abaft this again there are usually three oil cargo tanks on either side of a centerline bulk-

head. Then follows a pump room, sometimes recessed into the aft tank, and the engine room and aft peak tank, the latter sometimes containing fuel oil. Diesel engines, either direct coupled or with electric transmission, are used for propulsion almost exclusively and they have proved very economical. Accommodation is all aft, and in one ship where extra accommodation is required, this is secured by running a light structure as far forward as



Typical San Francisco Bay tanker of 3500 bbl. capacity, owned by Richfield Oil Co.

necessary over the deck, on stanchions, and constructing extra deckhouses and wheelhouses on this. A small pole mast forward with two derricks takes care of the cargo, the derricks being worked from winch barrels on the windlass. The Isherwood longitudinal system of construction has proved popular in these ships. Small expansion trunks about 30 in. in height extend over the length of the cargo tanks.

Service to and from the delta lands from San Francisco and other important points is carried out by a variety of craft, freight and passenger, sternwheel and screw. There are no outstanding craft which warrant any special discussion, however, since almost every local company has its peculiarities of construction. Some of the owners of ships own the shipyards which construct and repair them.

Ferries and towboats form an equally important part of San Francisco Bay local activity and these are discussed in their respective chapters.

San Francisco Bay Tankers

Dimensions L × B × D	Capacity	Remarks
175 o.a. × 36 × 7	150,000 gal refined oil 15 tons package	Speed 8 knots Direct Diesel Drive Extra accommodation on pillars over deck. Twin Rudders.
114.3 b.p. × 32.1 × 8.3	400 tons	Two Diesels for propulsion total 160 hp.
166 o.a. × 38 × 9.6	3500 bbl.	Two Diesels 220 b. hp. total 6 ft. 2 in. draft.
125.5 b.p. × 28.7 × 6.2	231 tons G	Sternwheeler Steam 200 i. hp. Refined oils and package Two decks and superstructure

The last example mentioned above is one of the old type sternwheeler tankers operating on the Sacramento and San Joaquin Rivers. She serves the farmers of the delta lands and carries refined oil products in bulk and in packages.

Details of Typical Sound and River Ships

Service or Duty Type	Length ft. Beam mld. ft. Depth ft. Draft ft.	Tonnage	No. Pass Decks Deck arrangement No. of Bulkheads
Sound Norfolk, Va. and Washington, D. C. Night passenger	305.5 o.a. 297.6 b.p. 51 18 12.75 load	1943 tons displ f.w.	3 Cabins aft on main deck fore and aft on saloon and gallery decks
Sound New York and Providence Night passenger	265 o.a. 246 46 15.5(to main deck)	1248 Gross	3 Cabins aft on main deck Cabins fore and aft on saloon and gallery decks
Hudson River New York and Albany Night passenger	317.2 b.p. 42.5 12.5	2571 Gross	3 Saloon: Gallery; Upper Gallery. Saloon deck is hull strength deck

Power Speed Kts	Machinery	Masts No. of funnels	Remarks
2400 i. hp. 104 r. p.m. 16	4 cyl triple exp. $23\frac{1}{2}$, 37, 43, 43x 42 in 4 S. E. Scotch boilers	1 no masts	Main deck is strength deck 3 superstructure decks Saloon: gallery Hurricane Flared midship section to main deck.
1700 i. hp.	Triple exp. S. E. Scotch boilers	no masts	Main deck is strength deck 2 superstructure decks:— Saloon: gallery. Pilot house at fore end of gallery deck Flared midship section to main deck.
2500 i. hp. 14	Inclined Comp.		Night river passenger packet Compare with Sound ships mentioned above.

Mass Transportation of Humanity

Is Seen in Large Excursion Ships on River Routes

THERE is in American waters a larger proportion of ships designed purely for pleasure or excursion purposes than anywhere else in the world, and this is largely attributable to the concentrations of population in big cities which are either seaport cities, like New York or Philadelphia, or on the shores of large bodies of navigable waters, like Chicago, or on rivers, like St. Louis. It is also correct to state that the excursion trade contains a larger proportion of ships over 25 to 30 years of age than any other maritime trade. This is for two reasons: firstly, because all excursion steamers operate on a schedule rarely exceeding six months' duration, being laid by for the rest of the year. During this period there is no wear and tear on the ships other than bottom fouling; secondly, because the great bulk of persons which, habitually and in large quantities, patronizes excursion steamers does not demand a high standard of luxury or cleanliness. Such persons generally can be attracted by cheap fares, dancing on deck, blatant publicity, and tawdriness beneath which many a 30 year old hull can hide its age. This is no slander on the splendid specimens of the naval architectural art which have recently been completed for this trade; neither is it a reflection upon the workmanship put into some of the old vessels now running. Rather is it a plaint that short distance water travel for pleasure should have sunk to such a low level of recent years until in this country, and in British waters, it represents literally the bulk transportation of human freight, in most cases regardless of comfort and in many cases regardless of safety.

Design Requirements

New York with its seven teeming, international millions, provides the largest potential "cargoes" for the excursion ship trade, and it is to the Hudson River that we must turn for the largest and finest examples of excursion ships, examples which go a long way toward fulfilling all the design requirements of this type. What are these requirements? Concisely they may be expressed as maximum open deck space with maximum number of decks on

Giant sidewheelers like this 400 footer represent the highest expression of excursion ship art and are found only on U.S. waterways.

a minimum of draft and freeboard. Furthermore, these decks must be raised above the strength hull and in order to assist in maintaining the small draft, must be of light construction, preferably of light wood with small iron stanchions supporting the deck edges. In this superstructure must be arranged the clear deck spaces together with dining saloons, rest rooms, toilets, dancing space, one or two cafeterias, checking room for personal effects, news stand, etc. In Great Britain, ships designed for this excursion work have no superstructure deck at all and suffer from restricted deck area in consequence. Neither do their sidewheel sponsons extend fore and aft as in American ships, where the deck is faired to run fore and aft into the normal deck lines of the ship, thus securing extra deck space. The American excursion ship carries machinery, stores, crew accommodations if necessary, and fuel, in a long, wide, shallow hull and then her passengers above in a light superstructure.

For a ship of this type, it is obvious that there are two important factors to be taken care of — the provision of adequate

stability and the guarding against the natural period of vibration of the propelling machinery coinciding with that of the hull, which transmits it naturally to the light superstructure. In addition, unless carefully strutted and braced, this latter may suffer severely from the ordinary "shaking" to which a ship is subject on rapid reversals of direction of motion of the propelling machinery, with consequent discomfort to the passengers.

Since draft is limited, and hence molded depth, great beam is practically the only thing which can secure a satisfactory metacentric height and this is partly the reason for the continued popularity of the paddlewheel for propulsion in this class of ship. By extending the main strength deck to fair in with the paddle box sides a large deck area is obtained, as previously explained, while the wheels themselves give the ship a virtual breadth without increasing the waterline breadth. In addition to this, paddle machinery of diagonal inclined type has a lower center of gravity than the vertical reciprocating type of prime mover, and this fact tends to keep low the center of gravity of the ship and hence to help maintain a large metacentric height. It is always necessary to provide for sudden, violent inclinations in ships of this type, caused by a body of passengers rushing suddenly from one side to the other — for example, when alongside a pier. Large trimming tanks can be fitted to guard against this, under easy control of the engineers. Furthermore, a paddle engine with usually two — at the most three — cranks placed athwartships is less likely to set up vibrations in the ship's hull than a fast running vertical prime mover with four cranks, or in the case of a Diesel probably six.

The above remarks should not be taken to indicate that a vertical reciprocating prime mover driving a screw cannot be fitted to an excursion ship. The sidewheel is possibly better, however, for the largest Hudson River ships than for more ordinary types. In a screw ship, the main deck edge can still be extended over the side and supported by diagonal struts, as in the case of Sound ships, or even a flared section may be adopted; but this is necessarily accompanied by an increase in waterline breadth over the

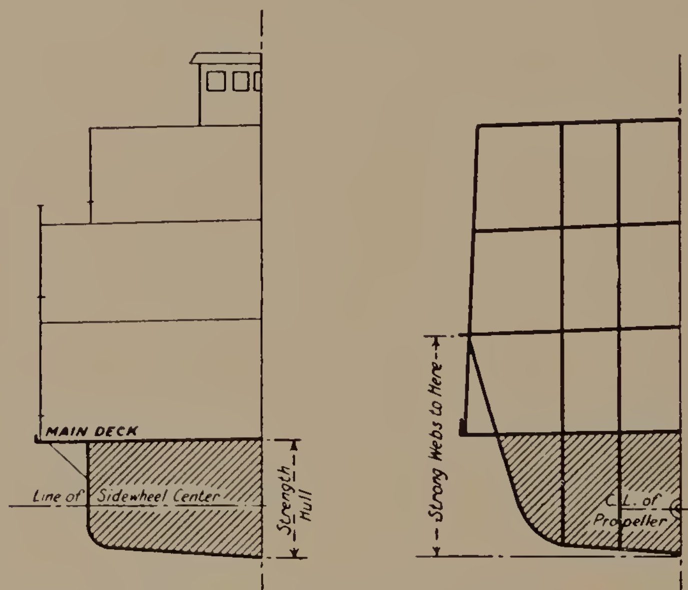
sidewheeler in order to compensate for the virtual waterline breadth given by the paddles. Thus, whereas the sidewheeler has her hull sides almost vertical with practically no tumblehome or flare, the screw ship has of necessity considerable flare.

Superstructure Bound to Hull

It has been mentioned that in the majority of pleasure ships, the structure may be considered as two distinct portions — (a) the main strength hull and (b) the superstructure. This has certain disadvantages, as we have seen. George A. Sharp, naval architect, New York, has gotten out a design now applied to a number of excursion ships, in which disadvantages of a separate superstructure and the dangers of excessive vibration are eliminated. The hull is constructed on a special system of trussed lattice framing consisting of wide spaced deep frames and beams from the keel to the first superstructure deck with steel tie beams at each of the superstructure decks above, combined with continuous vertical columns, run from the side fore and aft girders or keelsons on the ship's bottom to the uppermost superstructure deck. These columns are of one piece and are riveted at all intersections with beams, frames and floors. By this means, the superstructure, although still retaining its superstructure characteristics, is bound into the hull proper, contributing greatly to strength and to the elimination of vibration. The method also dispenses with the diagonal guard braces under the extended main deck. The difference in construction between this and the usual system is well shown in the illustration.

Hull structure in most excursion ships is on the frame and reverse frame principle, with floor plates and a bar or side bar keel. Longitudinal rigidity is secured by fore and aft girders under the deck and deep side keelsons, while in some cases rigidity is secured for the superstructure by vertical pillars in line on either side of the centerline of the ship extending to the topmost deck with diagonal wire rope braces, which can be tightened as required by means of turnbuckles. This system of securing

longitudinal strength, or rather of providing against deformation of the hull where this is a long shallow structure is not by any means confined to excursion ships, and it is very common on the Western Rivers. In excursion ships, however, it will probably be gradually replaced in favor of braced structures, such as that just described. The "tenderness" of these shallow hulls is well illustrated by the case of a large ship, 400 ft. x 47 ft. x 13.6 ft.



Sketch at left shows ordinary type of excursion ship structure and on right the "Sharp" special design.

molded, which was run aground on mud, to avoid sinking, in about 30 ft. of water. Her back became so badly broken that salvage was almost impossible and the owner abandoned the ship.

Dimensions vary with service, some of the largest excursion ships in American waters being found on the Hudson River. The maximum length is about 400 ft. between perpendiculars, and such ships have as many as four superstructure decks above the main deck. Diagonal engines of 6000 i.hp. give a 400 ft. ship a speed of about 15 knots loaded. It seems probable that both sidewheel and screw ships will be built for some years to come, since the sidewheeler has so many advantages. On the Western Rivers, — home of the stern wheelers — side wheelers

which are very close imitations of the large ships which made the record Mississippi runs of last century have been built for excursion purposes. These vessels have their paddles well abaft amidships and combine an enormous carrying capacity with practically no freeboard and very shallow draft. On the Sacramento and San Joaquin deltas, the sternwheeler has been adopted for passenger carrying work from San Francisco. This is also the case on the Columbia River between Portland and Astoria. The tunnel screw has made very little progress on these rivers for passenger work, although it has been tried out in towboats and freighter barges.

A comparison between a side wheeler and a screw vessel, both engaged in pleasure passenger work, the screw steamer on the Delaware River and the sidewheel steamer on the Hudson, is interesting since it serves to bring out a number of points already referred to in this chapter.

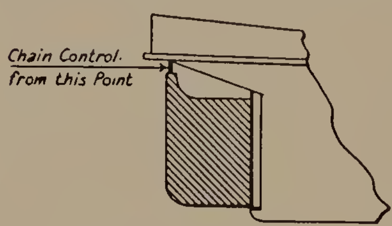
Comparison of Side Wheel and Screw Excursion Ships

Item	Length O. A.	Length B. P.	Beam molded	Beam at W. L.	Beam on guards	Depth Mld.	Draft	Total height	No. of decks above main deck	Power	Speed	No. of Pass.	Transverse trimming tanks
Side Wheeler	255	240	36.8	36.8	66	14.5	—	20.5	2	2200 i. hp.	17 kts	3200	2 10 ton
Screw Steamer	225	219	48.75	45.75	59	13.5	9.5	37.5	3	2900 i. hp.	18 mph	3500	2 18 ton

It will be seen that the paddle steamer has a much greater proportion of length to beam than the screw ship, the paddles permitting of a narrower hull with practically vertical sides. The screw ship has a breadth molded at 9 ft. 6 in. (load draft) waterline of 45 ft. 9 in., while at the main deck — 13 ft. 6 in. waterline — this has increased to 48 ft. 9 in. This is an increase of 1 ft. 6 in. in the half breadth, in a height of 4 ft., from which it will be seen that the angle of slope of the side of the hull is 21

deg. The overhang of main deck for the paddle ship is 14.6 ft., and for the screw ship 5.125 ft. on either side. The screw ship appears to be more highly powered for her speed and size than the sidewheeler, having one 4-cylinder triple expansion unit taking steam from two Babcock & Wilcox water tube boilers burning oil as fuel. The sidewheeler has an inclined compound engine taking steam also from two Babcock & Wilcox oil burning boilers. Both ships represent quite modern practice in their respective forms of propelling machinery, the screw ship in particular being a very efficient unit.

Protection against fire is an important matter on ships of the excursion type, which with their light superstructure are liable to burn very quickly. Wood should be eliminated from the structure as much as possible and special fire-resisting materials such as Plymetl used in its place. This is a combination of Plywood and steel composed of a three-ply panel, to which are added two faces of thin, double galvanized, stretcher leveled sheet steel. Watermains, supplied by large pumping units in the engine room, are generally arranged throughout the ship at convenient places and there is also a large choice of patent fire extinguishing systems with smothering characteristics. These are generally very effective. The best fire protecting and fighting system devised, however, may be rendered inoperative through panic, and it is in cases like this that a ship's stability is required to assert its qualities.



Sketch of old timer's rudder control.

Superstructure decks in most excursion steamers are continuous from stem to stern, but in certain cases of older ships the topmost deck is not continuous forward of the wheel house, while in other vessels even older the deck below does not continue to the bow. Modern ships generally have their pilot houses and officers' quarters on a special short superstructure deck. It is on the old beam-engined ships such as those operating between New York and its neighboring beaches during the summer months that one

finds the greatest variety of deck arrangements. These ships retain the old arrangement of actuating their rudders from the aft edge at the top, as the illustration shows, instead of from the rudder stock as is the modern way. Some of them are as much as 40 years old and they are the last surviving representatives of an era in steam navigation now past. Their engines are of magnificent construction and are still standing up splendidly to the work. Following are the dates of construction and principal dimensions of excursion steamers which were in service in the 1926 season:

Old Excursion Steamers in Service in 1926

Year completed	Material of construction	Length b. p.	Beam mold	Depth mold	Power	Where built	Remarks
1866	Wood	187	30.4	8.0	808	Hunter's Point, N. Y.	A veteran with Beam Engines
1880	Iron	314	14	10.1	3200	Wilmington, Del.	Side-wheel Beam engines
1889	Iron	272	44.1	12.6	250	Wilmington, Del.	Screw (converted)

It might be inferred from the above that the excursion shipbuilding industry is not progressive and speaking broadly this is so, because of the reasons outlined at the commencement of this chapter — paradoxical though it may seem in the light of American progressiveness in all other directions. There are of course notable exceptions to this and the girder construction previously described goes to show that naval architects are ready, on demand, to produce new and improved designs.

The Hudson River was not only the cradle of modern steam navigation — now rapidly giving place to internal combustion navigation — but also it has been the scene of some of the fastest smooth water "runs" that have ever been made. Hudson River Day Line now has some of the largest and finest sidewheelers in the world running between New York and Albany — worthy

successors of their illustrious forebears among which must be included the immortal *Mary Powell.* It seems therefore not without interest to close this chapter by including the schedule for ships on this run. The Day Line suffered a sad blow in the early Summer of 1926 by the loss through collision of the flagship of their fleet — *Washington Irving,* largest and finest river steamer in the world; but the service was maintained efficiently by the six remaining units — one of which, *De Witt Clinton,* built in 1913, is a screw steamer. A fine new ship, the *Peter Stuyvesant,* has since been added to the fleet.

NEW YORK - ALBANY (HUDSON RIVER DAY LINE)

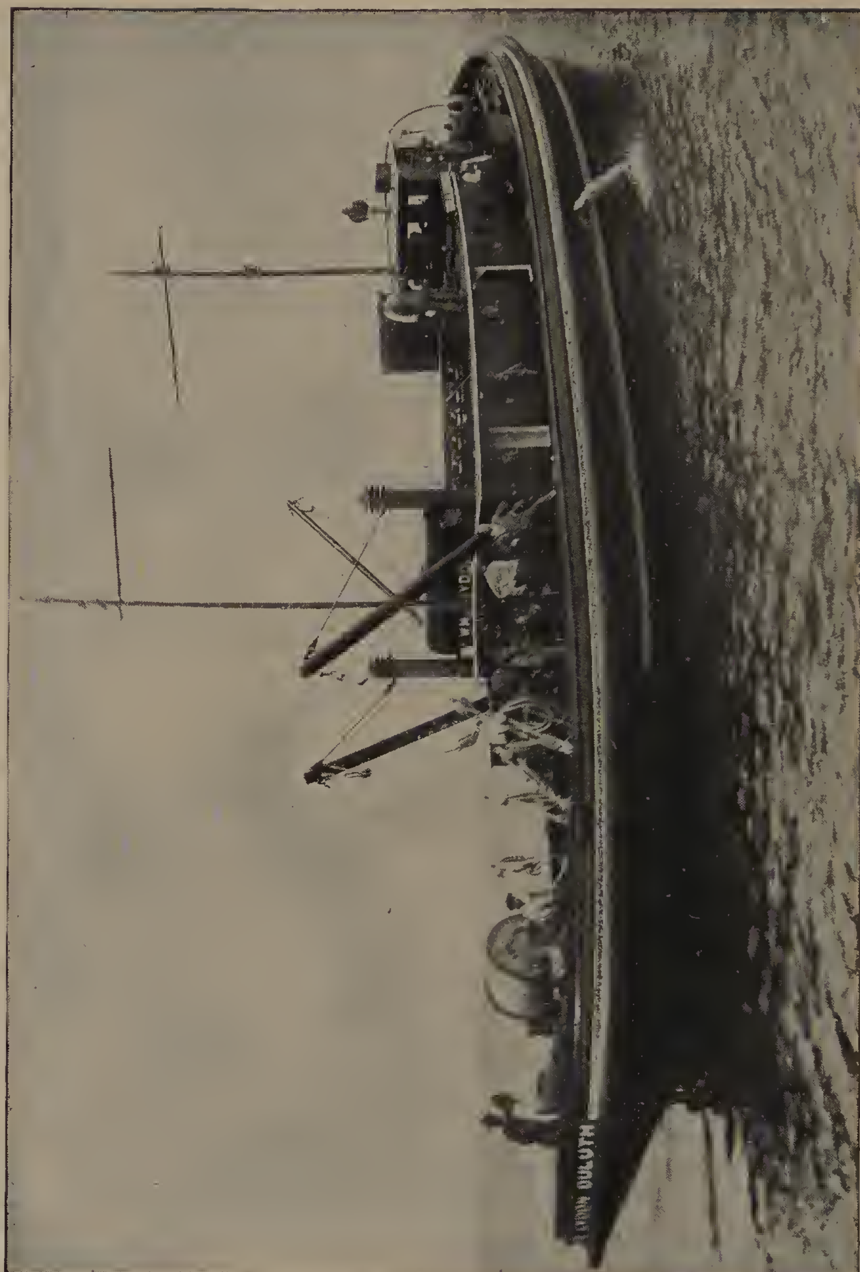
OUTWARD (Northbound)			HOMEWARD (Southbound)	
POINT	TIME	Dist. from N. Y.	POINT	TIME
New York			Albany..........Lv.	9 00 am
Desbrosses St....Lv.	9 00 am	—	Hudson.............	11 15
West 42nd St.......	9 20	—	Catskill.............	11 40
West 129th St......	9 40	—	Kingston Point.......	1 00 pm
Yonkers.............	10 15	17 m	Poughkeepsie........	2 00
Newburgh...........	12 40 pm	60 m	Newburgh...........	2 50
Poughkeepsie.........	1 30	75 m	Yonkers.............	5 00
Kingston Point.......	2 25	90 m	New York	
Catskill..............	3 35	115 m	West 129th St......	5 40
Hudson..............	3 55	120 m	West 42nd St.......	6 00
Albany..........Arr.	6 45	150 m	Desbrosses St .Arr.	6 30

Day Line ships are scheduled to make the 150 miles from New York to Albany with six intermediate calls in 9 hrs. 45 min. — representing an average speed of just over 15 miles per hour. Returning, the run is scheduled to be made in 9½ hrs., i.e. 15 min. less than the upstream run. Following is a time table setting out the times and points of call for a typical season. From these — although they are not always rigidly adhered to — some idea may be obtained of the rapid point to point runs, some of them averaging 18 miles per hour and over. Downstream the average speed is just over 15½ miles per hour.

U. S. Railroads as Shipowners

Are World's Largest Operators of Small Craft Fleets

AMERICAN railroads are the largest owners and operators of small craft in the world. Their fleets comprise ferryboats, towboats, passenger ships, car floats, car ferries, floating derricks, covered barges, refrigerator barges, and grain elevators, all of which are operated through a special marine department with its own chiefs and organization. These railroad fleets have very special duties to perform, and they do it in a remarkably efficient manner. Railroad principles and practice have been applied in many cases to the operation of these fleets with great success. The principal reason why railroads are such large operators is largely one of geography, as exemplified by the positions of large cities, like New York and San Francisco, on narrow strips of land — peninsulas, one might call them — and of others upon wide rivers and waterways like Norfolk, Va., Newport News, and Philadelphia. The requirements of modern New York and San Francisco, in particular those of the former, are the primary causes for the extensive railroad ownership of harbor craft at the present day. New York with its 7,000,000 population has but two railroad passenger terminals on Manhattan Island, both of which are used by two railroads, but only one of these four railroads actually hauls freight trains into the city and this is only a relatively small proportion of the total freight it handles. The greater proportion of the 170,000,000 tons of freight which enters New York each year is rehandled from the mainland to Manhattan by means of the towboats, car floats and barges of nine railroads, one only of which has freight and four of which have passenger terminal facilities within the city. In passing and in contrast it



Wm. A. Lydon, a powerful Diesel driven tug completed for salvage work on the Great Lakes.

may be mentioned that London, metropolis of Great Britain, with population comparable with that of New York, has within its bounds ten railroad passenger terminals, all of which have freight yards within their vicinity. The River Thames is devoid of railroad operated craft with the exception of a few ferryboats operating between Tilbury and Gravesend near the mouth.

San Francisco, situated as it is on a peninsula, requires to take much of its freight from the stockyards at Oakland, as well as passengers from points north and south. Railroad operation,

One of the busy Pennsylvania R.R. car float loading bridges in New York.

therefore, approaches the importance that it holds in New York, because of the position with respect to the sea and to the opposite side of the bay. San Francisco incidentally, like New York, feels the problem of automobile congestion, and takes care of this by means of several privately operated ships as well as by railroad ferries. Carquinez Strait — bridged by special ferries, the largest in the world — forms a valuable cut-off for Southern Pacific lines from the north to Oakland.

Philadelphia, situated on the wide Delaware River, has a large

daily passenger movement from one side to the other, taken care of by ferryboats, while a considerable amount of freight is moved on car floats by the Pennsylvania and the Reading railroads between wharves on the Philadelphia side and the terminal piers in Camden. This floating operation forms an important adjunct to the facilities provided by the P.R.R. company's bridge across the upper Delaware and the other through all-rail lines to and from New Jersey. The same railroad also has an important marine "link" in its system across Chesapeake Bay between Cape Charles and Norfolk, Va., which dates back for its inception to 1884 immediately after the completion of the through rail line down the peninsula to Cape Charles. It handles both passengers in transit from New York and Philadelphia to Norfolk, and passengers and freight such as perishable fruits and vegetables from the South. Passengers are transported in two steamers, each with accommodations for about 1000 passengers, the vessels themselves having a length of 250 feet and a beam of 42 feet. These ships are of stereotyped Sound ship type, with two decks above the main deck, the lower of which is continuous from bow to stern. Baggage is carried on the main deck at the forward end, being loaded through side doors. These steamers make the crossing between Cape Charles and Old Point Comfort in 1 hr. 50 min. and then to Norfolk in 2 hr. 55 min.

The freight ferry is operated by 9 tugs — one of which was the first Diesel-electric tug in Norfolk Harbor — and 10 steel car floats of special design, having a length of 330 ft. and a beam of 50 ft. with four parallel rail tracks. These floats fulfill practically the same function as car floats operated by the Canadian Pacific Railroad between Vancouver and Nanaimo, and in both cases the floats are towed behind the tug instead of alongside, as is the practice on rivers and in harbors. But whereas the C. P. R. floats are shipshape at the fore end with a built-up bow and Great Lakes type of pilot house, the P. R. R. floats are flat, open, double ended structures with a wheel house arranged on pillars amidships. Both these groups of floats are among the largest in the world. San Francisco has large car floats of practically the same size en-

gaged in transfer work from Oakland. The Norfolk-Cape Charles ferry operates on a 24 hour schedule all the year round except during the worst of weather. The trip takes four hours from terminal to terminal and about 26 freight cars are accommodated on each float. One tug takes one float at a time and tows through a steel cable 800 ft. long.

Typical Railroad Fleets

ITEM	Tugs	Ferryboats	Lighters (self-prop.)	Oil storage barges	Hoisting barges (mech.)	Hoisting barges (hand)	Scow barges	Coal and pumping barges	Covered barges	Refrigerator and heating barges	Grain boats	Car floats	TOTALS
New York C. R. R.	29	9	6	4	20	19	6	1	116	40	24	66	340
Baltimore & O. R. R.	13	3	3	–	9	36	1	–	62	8	—	53	188
Pennsylvania R. R.	38	17	6	–	22	44	—	–	93	11	—	86	317
New Jersey Cent.	14	10	5	–	32	13	23	–	41	—	—	29	169
Lackawanna	19	15	5	–	17	22	—	–	69	16	35	33	243
Erie R. R.	14	8	2	–	3	59	5	–	109	21	—	30	253
Lehigh Valley	16	—	4	–	20	30	1	–	81	14	43	32	241
Long Island	7	—	–	–	—	—	—	–	—	—	—	8	15
N. Y. N. H. & H.	14	—	1	–	—	—	—	–	—	—	—	49	64
Ont. & Western	1	—	–	–	—	—	—	–	—	—	16	—	17
Reading R. R.	21	6	–	–	—	—	1	–	—	—	—	—	28

Cars are moved on and off the floats at the terminals by shifting engines over single span transfer bridges which are hinged to the dock at one end and rise and fall with the tide at the other end by means of the pontoons on which they rest. There are two bridges at Cape Charles and four at the Norfolk terminal. Tugs place the floats at the bridges and the latter are locked in position by two sliding steel bars through pockets on both floats and bridges, to align the tracks. The floats are also moored by cables, as a precaution. During peak movements of traffic a float can be completely unloaded and loaded for return in about 18 minutes. The average time is one hour, the movement being governed by the rail movement in the yard.

Baltimore & Ohio Railroad is another large marine operator and where its tracks terminate in seaports, the work of transporta-

tion is carried out by towboats, car floats, ferryboats, etc. Large car floats are maintained at Newport News of a type similar to those used by P. R. R. on its Norfolk-Cape Charles Service. The units of its fleet are distributed between New York (Brooklyn and Staten Island), Philadelphia, Newport News and Baltimore. Details of the "make up" of the B. & O. fleet will be found in the following table, correct for the year 1927, of typical railroad fleets. Numbers in almost every case have probably altered since then; but where they have done so, it has been proportionately, and the value of the table lies in the fact that it gives an idea of the proportional distribution of types.

The railroads mentioned above, it will be noted, have no sea-going vessels either passenger or freight. This fact it is interesting to contrast with the British and Canadian railroads which, with the exception of a few towboats and a dredge or two, have nothing but fast cross channel ships, comparable in size to, faster in speed than, and in some ways inferior in arrangement to the American Sound ship, as has been indicated in a previous chapter. Southern Pacific is the only American railroad with large sea-going passenger and freight ships and these, as we have seen, form an important connecting link from North and East to South and, via the railroad, to West. This railroad operates also ferryboats in San Francisco Bay, and it placed its first order for six Diesel driven ships of this type in September 1925. The passenger ships operating in Southern Pacific coastwise trade between New York and New Orleans are vessels of 3,500 to 6,000 tons gross. The illustration opposite shows a Southern Pacific ferry slip at San Francisco.

During the summer season Central Railroad of New Jersey operates two fast passenger ships — usually known as the New Jersey Flyers — from New York on the Sandy Hook Route. It is to be recalled also that the Central of Vermont R.R. operates the Lake Champlain S. B. Line. The Illinois Central and the Ocean SS. Co. are closely connected, while the New York, New Haven and Hartford R.R. owns the New England SS. Co.

When railroads operate floating equipment, they generally

do so efficiently and for certain work there is much to be said for the application of railroad principles to shipping. In Great Britain, more than in this country, private shipowners have attacked railroad ownership of vessels on the grounds of unfair competition, because they urge that the railroads can operate

One of San Francisco's busy ferryboat terminals showing big Southern Pacific R.R. Craft in the slips.

through sea and rail services at freight and passenger rates which would leave no margin of profit to the shipowner. This is true because the railroad considers the sea portion of any particular journey merely as part of the complete journey. The profit must be shown on the complete journey and not on the part. Thus in the journey from London to Paris, the Dover–Calais portion need not *per se* show a profit, but the complete London–Paris portion must do so. Railroad ownership of this kind has the advantage, to the railroad, that it can control traffic on the whole of the route instead of on its own tracks on one side of the water portion.

This example has an analogy in ths country in ferry routes,

which enable the passenger to purchase a through ticket from, say, a point on the Manhattan side of the Hudson River to some point in New Jersey. The ferry journey is merely an incidental in the complete journey. Railroads control most of the ferryboat routes in the large shipping centers, the number of privately owned routes being comparatively negligible. The railroad-owned ship has the advantage of the entire marine organization of the company in the way of shops and docks for repair and overhaul and is in consequence always in a good state of maintenance. The same applies to towboats and is instanced in a rather noteworthy manner in the early history of the application of Diesel engines to this type. Most towboat owners from about 1922 onwards realized the potentiality of the Diesel for this work and many tried out different types of drive. More versatile in this than any private owners were the railroads, some of whom went straight to the Diesel-electric system and others to geared forms of drive — all of which represented a larger capital outlay than a direct drive. The more wealthy owners were inclined to follow this arrangement also, whereas the smaller owner went to direct drive.

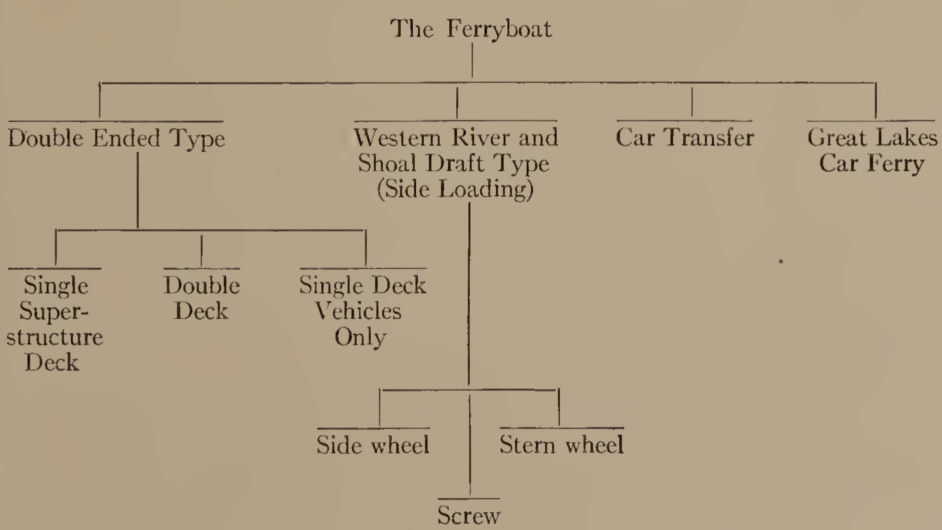
The remarks in this chapter serve to introduce the subject matter of the next two chapters; viz., Ferryboats and Towboats, in both of which types railroad ownership is so deeply interested.

Four Big Groups of Ferryboats

Help Out Transportation Problems on Seaboards, Rivers, and Lakes

THERE are four groups into which, for analytical treatment, ferryboats can be placed, by reason of some dominant characteristic. Thus, there are the double ended vessels employed on most of the harbor routes, a great number of which are railroad owned; the sternwheel and sidewheel, side loading types employed on the Western rivers; the large sidewheel car transfer type employed by railroads to avoid long detours; the car ferries employed on the Great Lakes. The first group is the most numerous and can be further subdivided into single and double decked and exclusively vehicular types. For the sake of clearness, however, it is interesting to show the family tree of the "genus" ferryboat before dealing with each group in greater detail.

"FAMILY TREE" OF FERRYBOATS



The Double Ended Type

The double ended ferry is essentially American; it is mainly of New York and San Francisco; it has been evolved inevitably and slowly to meet the problems of the rapid transport of people and vehicles between congested areas separated by water. It is an efficient unit of transport because it permits of unloading the maximum quantity of transportable matter in a minimum of time and can take on board the same maximum quantity for a return trip without any preparations other than the reversal of the main engines and steering from either end. This ability is largely a question of terminal facilities in addition but it demands very definite characteristic in the design of the ship itself. The double ended ferry for passenger and vehicular work is to be found only in American waters. There are double ended ferries in Danish waters but these are used solely for transporting railroad cars. Two ferry routes of this type exist between Esbjerg on the eastern Jutland seaboard and Copenhagen, the ships operating them being virtually car floats with a superstructure.

Double ended ferries allow a straight through movement of traffic impossible with a side loading ferry on which it is necessary for the traffic to sort itself out before unloading. To reduce the consideration to a mathematical viewpoint, a double ended ferry "in the limit," when the width of waterway becomes indefinitely small, is a floating bridge. A double-ended ferry is only a practical proposition when terminal facilities permit of running into special slipways out of the sweep of current. Such terminal facilities are expensive and are only possible where large traffic exists, such as in big cities. This is the reason for most Mississippi ferries being side loaders.

Constructional Details

In examining the characteristics of this type, one finds again the features common, in varying degrees, to most types we have dealt with so far; viz., the placing of all accommodation on a main strength deck, with light superstructure above. These, counting

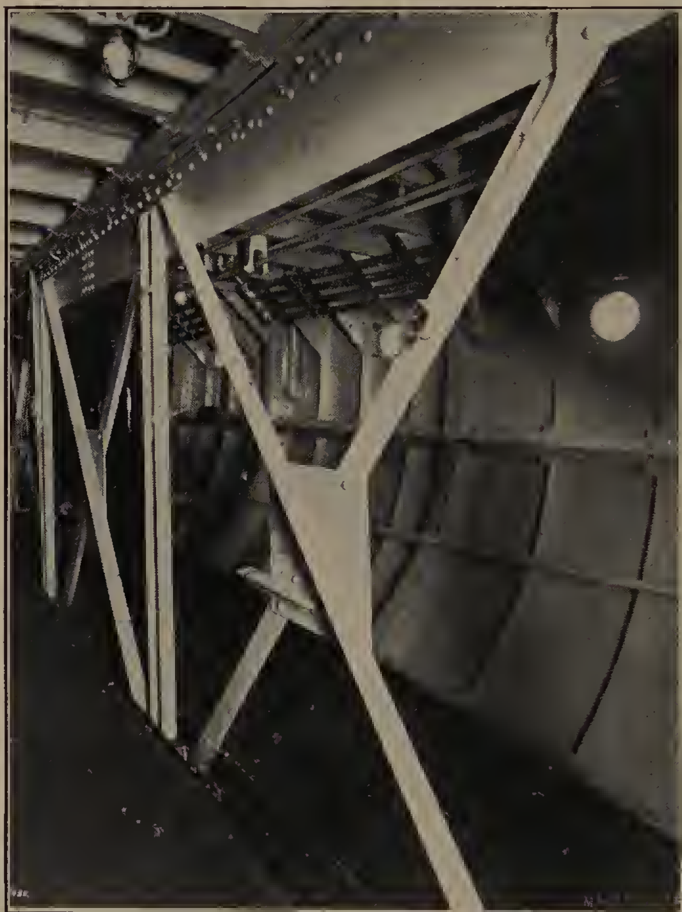
the fact that the hull is self-propelling, are the main distinguishing features between the car float and the ferry. All vessels now operating are direct descendants of the old sidewheel, wooden hull type with beam engines, a few of which could be seen operating on some rivers as late as 1926. These old ships had reverse sheer and a very large camber to the top of a superstructure covering the main deck and having a circular wheel house at either end. The main driveways for vehicles were in the center and the familiar cabins labeled MEN and WOMEN on either side of the

The old sidewheeler with walking beam from which the modern ship has evolved.

driveway — a custom which has survived to the present day. Viewed from a three-quarter position, one of these old ships with her walking beam waving in apparently crazy manner in the air, a coil of black smoke unrolling from her tall, thin stack, presented a very unusual appearance, and the rapidly revolving non-feathering sidewheels aided the illusion that the vessel was a startled creature running quickly over the surface of the water to escape from some dangerous enemy.

The modern vessel is constructed of steel and moves quickly from terminal to terminal at 16 knots, driven by electric motors taking their current from Diesel generators. Dimensions vary in accordance with the duty; but construction is much the same in each case, steel being employed everywhere except on certain

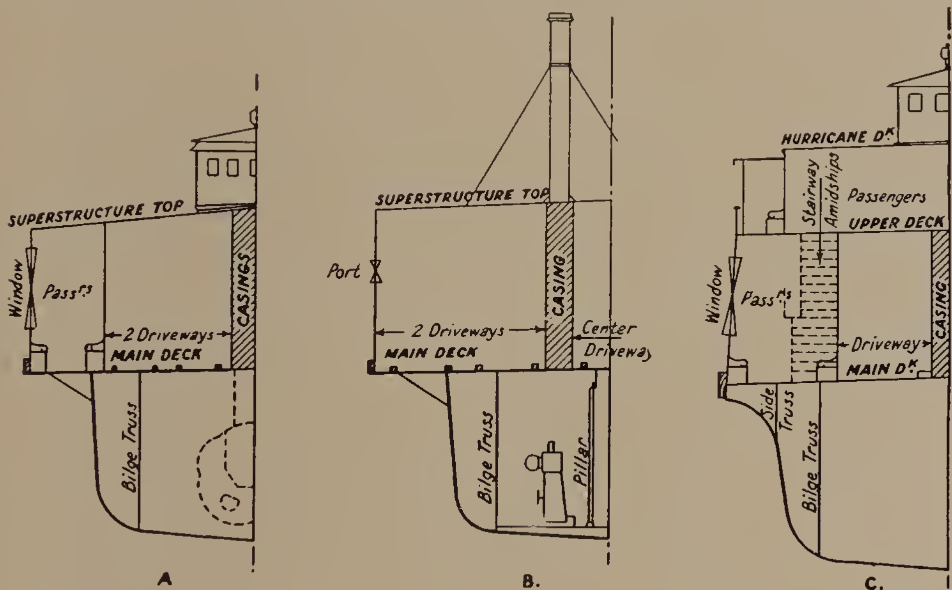
parts of the western seaboard where wood is relatively cheap. The detail tables show the dimensions and other leading particulars of typical ferries, and the proportions of dimensions can be seen from this. Longitudinal strength is a factor of some importance on account of the heavy deck loads caused by the



Detail of fore and aft truss girder construction in ferryboat.

vehicular traffic — alternately of a static and a rolling nature. For this reason, the Isherwood longitudinal construction has been adopted in a number of recent designs and has proved very successful. Where this is not used, a frame and reverse frame construction is adopted in conjunction with one, and in some cases two, fore and aft truss girders spaced at varying distances from the centerline of the ship in accordance with the size. Parts

of these fore and aft trusses, if plated, form the boundary bulkheads of side fuel tanks. A more general practice where liquid fuel is used, however, is to use cylindrical fuel tanks and to arrange them in spaces forward and aft of the machinery space. A ferryboat with a breadth over guards of 66 feet — which incidentally is the breadth molded of the hull, because the ship has a flared midship section — has one bilge truss and one side truss on either side of the fore and aft centerline. The bilge truss



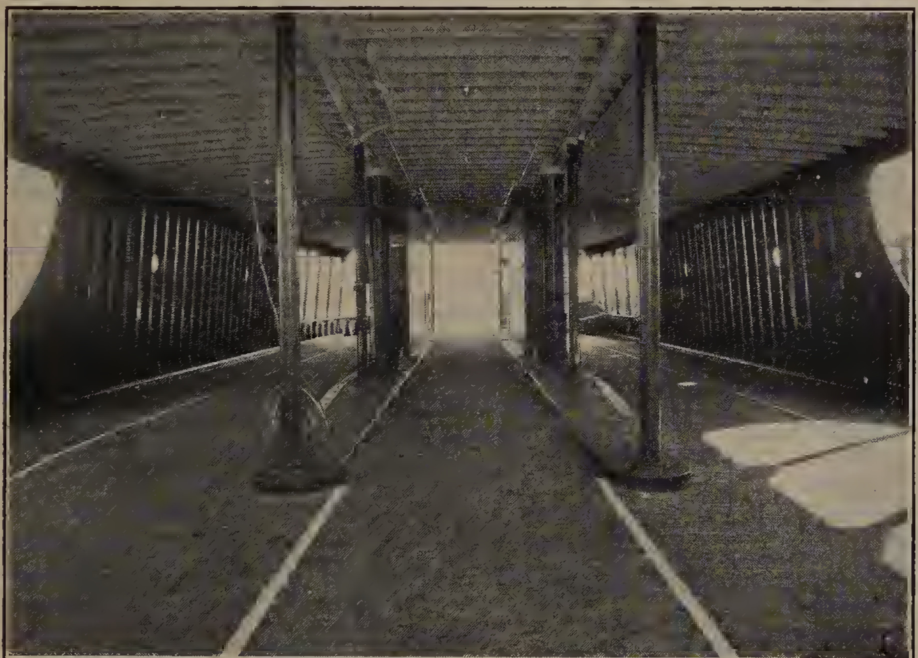
Sketches A, B, and C, above show alternative arrangement of decks, driveways, and passenger accommodation in ferryboats.

is spaced 14 ft. 5 in. from the centerline; it is composed of 6 in. x $3\frac{1}{2}$ in. x 15.3 lb. vertical channel bars at each web frame with 3 in. x 3 in. 2 7.2 lb. diagonal angle bars between. This vessel has 22 in. deep floors at the centerline and has $5\frac{1}{2}$ in. x 3 in. x 11.2 lb. frames with reverse frames. Hold pillars 10 in. diameter are arranged on either side of the machinery casing, which is 7 feet wide and is at the center of the ship. An 11 ft. driveway is at either side of the machinery casing and outside this again is a passenger cabin 18.5 ft. wide. This ferry is of double decked type and has another cabin above, and above this again a deck containing the wheelhouses, stacks, ventilators, and

boats. Ferries with wooden hulls are also reinforced by steel trusses worked into the hull structure, one recent vessel built for service on San Francisco Bay with an overall length of 240.75 ft. has a fabricated steel truss girder extending approximately over 70 per cent of the length. This extends the full depth of the hull structure amidships, resting on deep fore and aft timbers, and tapers off practically to zero at the ends. The vessel is of double decked type and has Diesel-electric propulsion, in conformity with best modern practice.

In the first example quoted above, two driveways are arranged on either side of a central machinery casing. An alternative arrangement is that in which the casings are virtually split into two narrow portions on either side of the fore and aft centerline, exhausts from the Diesel engines or boilers being taken up into twin stacks. This arrangement allows three driveways and considerably increases the vehicular capacity of the vessel although it may reduce the width of passenger cabin in a single decked vessel. This latter is not an absolutely fixed figure for a given molded breadth of hull, however, because the breadth over guards can be increased within reasonable limits to take care of these requirements. A case in point — a single decked ferryboat — has a beam molded of 37 ft. 6 in. and a beam over guards of 53 feet. Passenger cabins, arranged on either side of the vehicular space, are 7 ft. 9 in. wide. They are actually, as the dimensions show, on the guards and may, on this account, be regarded as oblong boxes attached to the side of the vehicular space in the center. The guard brackets and braces are heavily constructed and strongly attached to take care of this weight. Machinery casings are arranged in two portions 3 ft. wide, each spaced 11 ft. 6 in. centers from the centerline of ship. Center driveway has a clear width of 10 ft. fore and aft, and the two side driveways a clear width of 10 ft. 1 in. amidships. Two rows of $3\frac{1}{2}$ in. pillars are worked in way of center driveway in the machinery space amidships while 6 in. x $3\frac{1}{2}$ in. x 15.3 lb. channels are run forward and aft of this. Two bilge trusses are fitted.

A further interesting example of distribution of members is that of a vessel specially designed for carrying automobiles between Sewall's Point, Norfolk, Va., and Newport News. The machinery casings are amidships and three driveways are arranged on either side, the deck being quite free for vehicular traffic, passenger accommodations being on the superstructure deck. The beam molded at main deck is 46 ft. 8 in., while the beam over guards is 13 ft. greater. Two longitudinal truss girders are worked, one on either side of the centerline.



A 5-driveway arrangement in a vehicular ferry. Note the narrow machinery casings.

It will be observed from the above that the vessel with the flared midship section has two longitudinal truss girders on either side of the centerline. The outer truss in this case corresponds virtually to the normal line of the ship's hull. A legacy of the old sidewheel days is to be found in the majority of modern ferryboats in the overhanging main deck — a legacy also to be found in excursion ships as we have seen already. This is emphasized by the fact that it is still customary to speak of the "breadth extreme" of the ship as the "breadth over guards";

i.e., meaning breadth over paddle guards. The flared midship section is the logical follower of the plated-in guard stanchions and brackets, as in the case of the Sound ship, but is not so common in the case of ferryboats. In some cases, the main beams are continuous in that they include the guard portion; but in other ships they are bracketed securely to the ship's side, being generally of the same scantling as the main deck beams but spaced on alternate frames. In cases like this, passenger spaces are generally arranged on the guards alongside the vehicular space.

Constructional Characteristics of Ferryboats

Beam molded	Beam over guards	Depth molded	No. of machinery casings	Width	No. of driveways	Width of pass. spaces	No. of working decks	No. of trusses	Width of driveways	REMARKS
66 ft.	66 ft.	19.5 ft.	1	7 ft.	2	17.5 ft.	2	4	11.1 ft.	Flared Midships Section
37.5 ft.	53 ft.	14.25 ft.	2	3 ft.	3	7.75 ft.	1	2	10 ft	Side by Side Stacks
46.8 ft.	59.8 ft.	15.2 ft.	1	11.8 ft.	6	— ft.	2	2	12 ft.	Passengers on Top Deck only
45.0 ft.	64.0 ft.	19.0 ft.	1	8.25 ft.	4	— ft.	2	2	10.8 ft.	Passengers on Top Deck only

General Arrangement

General arrangement varies with the duty and ranges all the way from the plain flat open decked type for dealing with auto traffic only, in which a light hurricane deck structure is built over the main deck, to the palatial "liners" of San Francisco Bay with main, upper, and hurricane decks containing passenger and vehicular accommodation on the main deck, and passenger quarters

on the upper deck inclusive of ladies' rest rooms and restaurants. These ferryboats are the largest and most luxurious on North American waters; or, for that matter, on any waters. They are closely rivalled by the 16 knotters on the New York (Battery Park) – Staten Island (St. George) route, except that these vessels have no restaurants. Terminal facilities of great efficiency on this and similar routes permit of passengers being loaded direct on to the upper deck as well as on to the main deck, although interior stairways connect the two decks, amidships or at each end on both sides in the "Men" and "Women" cabins. These

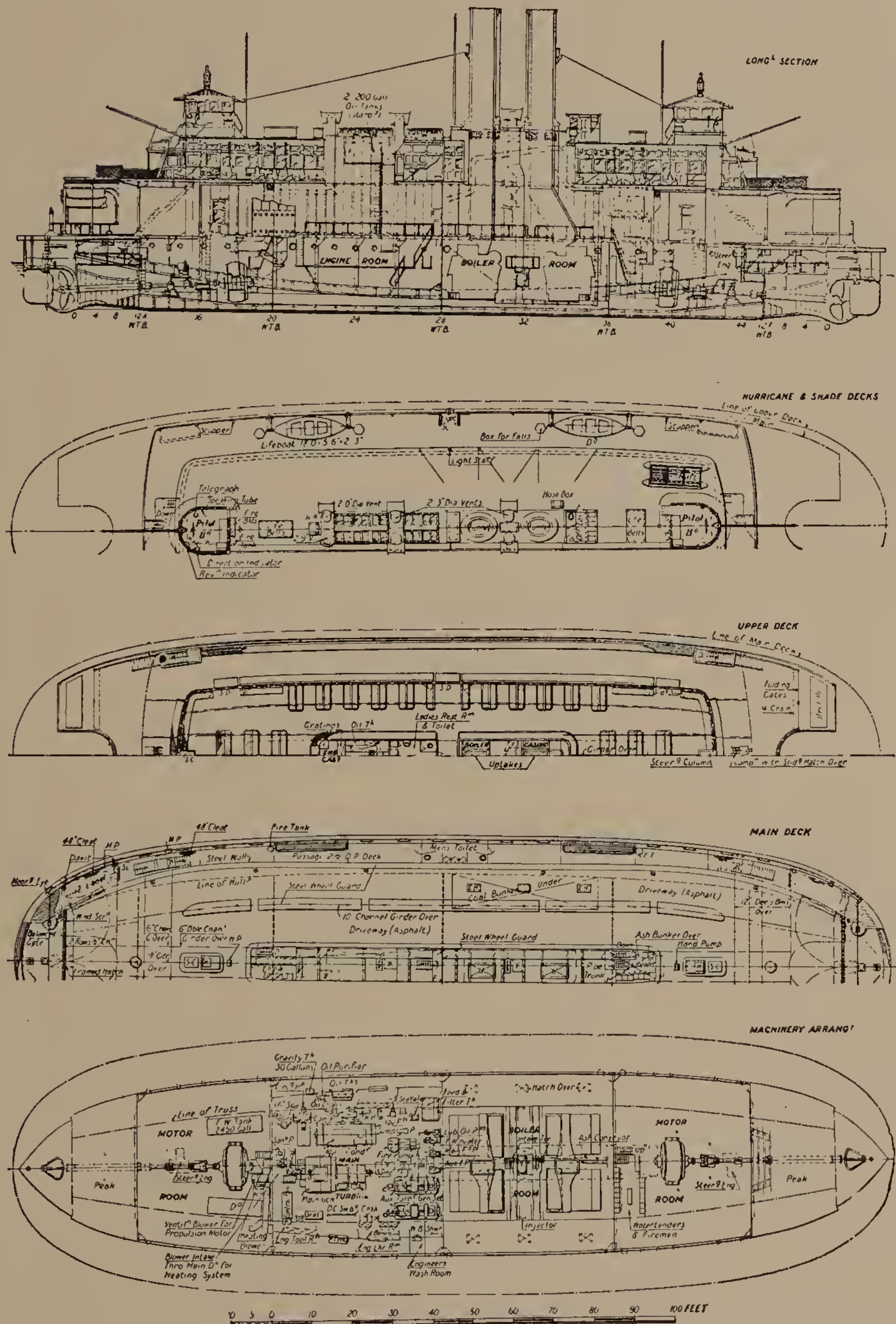
The big Chesapeake ferries have restaurants and state rooms for passengers.

stairways lead up in both directions and are plentifully bespattered with warnings to passengers not to descend when the vessel is entering her slip — a wise precaution, because the inevitable bump as the ship hits the side stakes of the slipway is more than likely to precipitate passengers to the bottom of the stairway with more speed than dignity. As a matter of fact, these stairways are not much used when two deck loading arrangements are provided at terminals; but they are very desirable for ready access from deck to deck in the event of fire or collision — from both of which dangers American ferryboats are singularly free, though many are by no means fireproof. New York railroad-owned ferries favor the midships stairway. In other ships they

are toward the end of the superstructure, some outside and some inside.

New York ferries provide seating accommodations, lavatories and wash places only. Norfolk ferries provide in some cases restaurant facilities and have separate cabins for white and for colored people. Ferries on the Chesapeake such as those operating between Clairbourne and Annapolis, Md., have restaurants and state rooms on three passenger decks. These ships make very long runs. Some San Franciso ferries have restaurant facilities and well fitted rest rooms. In a general way, it may be noted that West Coast ferries — particularly those operating in Puget Sound — have a bigger 'tween deck height and a more square ended superstructure than the Eastern ferries. In New York, those vessels intended for two deck loading, have their Upper Decks recessed at each end, which has the effect of producing two "pens" into which passengers are automatically forced on their way to the gangways leading off the ship. On a particular ship of 66 ft. breadth over guards, a parallel portion 12 ft. 9 in. wide and 8 ft. 3 in. long is removed; at its end it is "radiused" in a semicircle of 12 ft. 9 in. diameter. This will be noticed in the general arrangement of the ferryboat shown opposite, based on an article appearing in *Shipbuilding and Shipping Record*, London. This general arrangement should be followed closely with the foregoing text.

Sufficient metacentric height must always be provided to insure a "stiff" ship under all conditions of loading, heeling and trim. It must be remembered that human freight, when transported in bulk either on ferryboats or excursion ships, has all the bad characteristics of a bulk cargo such as grain or coal, in addition to the danger of panic. A mad rush of passengers from one side of a ferryboat to the other may easily put the deck edge under. For this reason the flared section has much to recommend it, since with heeling, it gradually increases the load water-plane area and hence the "I" factor in $BM = \frac{I}{V}$ which, with comparatively small alterations in "V" tends to increase "BM". As a specific



General arrangment of a big double ended electric ferryboat operating in the port of New York on the Staten Island run.

example, it may be mentioned that a ferryboat with 48.5 ft. breadth extreme has a metacentric height of 11 ft.

When approaching the slips at the termination of a trip passengers naturally crowd to the unloading end of the ship and tend to put her down by the head. Trimming tanks are not usually operated to counteract this because the trim by the head so caused is comparatively of a temporary nature; but it is conceivable that these might be useful, in conjunction with fast running, high-capacity pumps for emergency purposes.

The ends of the main deck are usually semicircular and they fit conveniently into corresponding recesses in the landing gangways, the ferry being held by ropes or pins on each side. Approaches to the ships are marked and protected from the current by wooden upright piles lashed and bolted together and having plenty of "give" so that in the last few yards of her journey, the vessel is practically hemmed in sideways. The face boards of the piles are coated with thick grease to minimize the force of glancing blows. By keeping her engines turning slightly ahead, the ferryboat when berthed can keep her nose hard up to the slip end.

Maneuvering and Machinery

Indicative of the progress the Diesel engine is making for ferryboat propulsion, it may be mentioned that one large railroad operator of such vessels has the whole of its fleet scheduled for conversion when individual replacements become due, while another railroad company, owning a large fleet of ferryboats, hitherto exclusively steam driven, ordered, in 1926, 24 big Diesel engines for installation in electric ferryboats. This is important in discussing the requirements for ferryboat machinery. In the first place equal maneuvering ability ahead or astern is required — in fact, there should, in the double ended ferry, be neither "ahead" or "astern" movements, since "astern" is really "ahead" in the opposite direction. In a well operated ferry, as a matter of fact, there is far less maneuvering than in a tugboat. She leaves one terminal slip and proceeds under ordinary

conditions straight into the opposite slip and the only reason to justify a reversal in direction of rotation of the main prime movers is in order to take way off the vessel in the event of her approaching the opposite slip too fast, or if another ship is in her course. A competent pilot can run his ship straight into her slip without any maneuvering of the main engines whatsoever and then he can walk along the hurricane deck to the other pilot house and take the vessel out again.

Propulsion is carried out in modern ferryboats mainly by the screw propeller, the paddle wheel being a rapidly disappearing survival of the past. Its many undoubted advantages are possessed and more than outnumbered by the large diameter big pitch propellers now in use. Two propellers are fitted, of course, to every double ended ferry — one at each end and in rare cases two at each end — each arranged to drive in the opposite direction to the other so that while one is driving, the other is pushing. It is obviously wise to have both in operation at the same time in order to avoid dragging a "dead" unit through the water and this has had an effect upon the arrangement of propelling machinery, and has, where the source of power is direct coupled to the propeller, necessitated the fitting of a single prime mover with crankshaft connected to a propeller at either end with a straight through shaft. Two tandem units operating separately would be complicated and possibly uneconomical to operate.

There are three possible machinery arrangements at the present time and these are direct steam, direct Diesel, and Diesel or steam-electric. Of these, the Diesel-electric is without doubt the installation of the future for large ferryboats and the direct coupled Diesel for smaller boats.

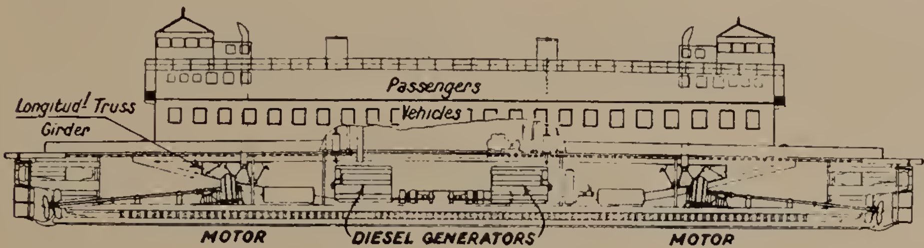
The direct-steam arrangement consists of a compound or triple-expansion reciprocating engine arranged with the usual auxiliaries in an engine room adjacent to a boiler room from which it is separated by a watertight bulkhead. The thrust shaft runs the length of the ship — under the boilers for part of the length — the two thrust blocks being at either end of the engine. Reversal of the engine obviously means reversal in direction of motion of

the ship because of the opposite turning wheels. Control is on the engine and is carried out by bell orders from the pilot house. An actual example (195 ft. overall by 59 ft. 8 in. beam extreme by 15 ft. $2\frac{1}{2}$ in. depth molded) has a compound engine 17 in., 34 in. by 24 in. stroke, developing 1150 i.hp. at 125 r.p.m. and driving four bladed cast steel propellers 8 ft. diameter by 12 ft. pitch. There are two steering engines, one at each end at engine room floor level, rod controlled from the bridge.

The direct-Diesel arrangement is the same as for the direct steam, except that boilers and other auxiliaries are absent. Control is on the engine and a direct reversing unit is fitted, which calls for an ample supply of starting air for rapid maneuvering in case of emergency. Such an arrangement has all the advantages and economies of Diesel propulsion, however, and they are especially patent in the case of ferryboats. The vessel can operate for much longer periods since she does not require to take on water or fuel so frequently. She has a lower fuel consumption and no stand-by losses, and full power is available the moment it is required. With direct-Diesel drive, too, space is saved over the corresponding steamer, both in smaller fuel capacity and in absence of boiler room; but it is doubtful whether, in a large vessel, this benefit can be used to its fullest extent because deck space, not hold space, is the important factor in ferryboat design. And however compact the machinery, a given number of passengers cannot be compressed into a smaller deck space. The direct-Diesel system of drive is useful in the small type of ferryboat. In both direct-Diesel and direct-steam, however, the long length of shafting with its many bearings (a 246 ft. steamer has nine) is a mechanical blemish. An actual direct-Diesel ferry (101 ft. 6 in. overall by 30 ft. beam extreme, by 11 ft. $11\frac{1}{2}$ in. depth molded) has a 6-cylinder 4-cycle trunk piston engine developing 300 s.hp. and driving a cast steel propeller 5 ft. 3 in. diameter by 5 ft. pitch.

Electric propulsion, whether the power be supplied by Diesel or by turbo generators, has a number of advantageous features possessed by neither of the two above methods. The Diesel gen-

erator combines in the ship the economies of this type of prime mover with the flexibility of electricity and the electric motor is becoming the accepted machine for propelling large, fast modern ferryboats. The fact, too, that it is a smooth running rotary prime mover is valuable in eliminating the vibration in the light superstructure inseparable from a large reciprocating prime mover direct coupled to the propellers. Flexibility, of course,



Big Diesel-electric wooden ferryboat operating in San Francisco Bay.

is the keynote to this type of drive, permitting the pilot to have absolute control of his ship from the pilot house without altering in any way the speed or direction of rotation of the main generator prime movers which, in the case of Diesels, operate smoothly without any sudden starting, stopping, and reversals. Usually the arrangement adopted is to place one or more generators with their auxiliaries amidships and to drive each propeller independently by an electric motor situated at the ends of the ship. This has two advantages — the elimination of the long lengths of shafting and the possibility of concentrating the power on the propeller actually driving the ship. It has been found that by running the propeller which is temporarily in the bow of the ship at a slower rate, it is possible to save an amount of power at least equal to the losses in the electrical system.

There are cases, however, in which one propulsion motor is arranged near amidships connected at either end to shafting and a propeller in the same way as in vessels with reciprocating prime movers. This arrangement has been adopted in the six ships constructed in 1926 by American Brown-Boveri Corporation, for Electric Ferries, Inc., New York, for their vehicular services on the Hudson River.

In sidewheel ferries such may still be found in places on the Western rivers, where one generator set is fitted, individual motors are used for each wheel. Either can be controlled as regards speed and direction of rotation independently of the other. In addition to this, the electric motor acts as a speed reducing gear and permits of the operation of the wheel at its best speed for efficiency. Following is a table giving particulars of some recently constructed Diesel-electric ferries.

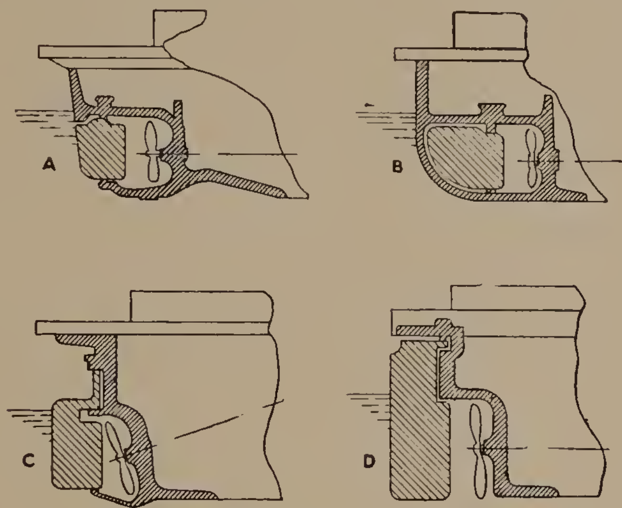
POWERING DETAILS OF DIESEL-ELECTRIC FERRIES

Length O. A. of ship	No. of Motors	Power of Motors each	No. of Generators	Output of Generators in Kw.	Power of Diesel	Operating Cycle	No. of Cylinders	R. P. M. Generators	R. P. M. Motors
256	2	1250	4	275	400	4		320	130
240	2	900	3	270	400	4	6	—	180
131	1	580	2	240	350	4	6	280	180
	Motors		Generators						

Sketches show the various arrangements adopted for the rudder, propeller and sternpost casting and make some interesting contrasts. This arrangement is one which is largely left in the designer's hands. Sketch *A* is the more usual arrangement in which the forward edge of the rudder acts as a stem continuation. *B* is an arrangement specially made for some vehicular ferries in which the rudder houses behind and is protected by a definite stem casting. *C* is in use on wooden ferries of the Diesel-electric type on San Francisco Bay. The rake of propeller shafting, common to most electric ferries, is noticeable. *D* is an unusual form of elongated rudder, also hailing from San Francisco — on a steamer. Most rudders are of "plate" type, but a few "built" units are still placed in service.

Ferryboats Other than Double-ended (Shoal Draft Type)

Ferryboats other than the double-ended type discussed above, which are confined to bays and harbors, are operated mainly on rivers, and most of them have to work in shoal draft water. Traffic is not nearly as heavy as on the double-ended routes.



Rudder and "end" arrangements adopted on ferries.

Generally speaking speed of loading and unloading is not a vital point and these considerations do not justify elaborate and expensive terminals, and in many cases the stream is too swift to permit of end-on loading and berthing. To illustrate what is meant by the importance of rapidity of loading and unloading of trucks and automobiles in congested areas, we can consider the cumulative effect of delay upon an important auto-ferry route such as that between Weehawken, N. J., terminal of the New York Central R. R. and West 42d St., New York. After and during a public holiday, a queue of automobiles almost $\frac{3}{4}$ mile long may be seen waiting on the New Jersey side for ferry accommodation to return to New York. Speed of loading such as that given by an end-on unit is the only possible means of taking care of that queue and the breakdown of one unit in what is virtually, at peak hours, an endless belt would cause crowding and congestion at either terminal which it is not pleasant to contemplate.

On the other hand, consider routes such as those running across the Mississippi River between comparatively sparsely populated districts. Such ferries have a capacity of about 12 automobiles. They operate possibly 30 or 40 weeks in the year and have a shoal draft of around 3 ft.

It is scarcely to be wondered at therefore that one finds a wooden stern wheel craft with machinery and pilot house aft, and a clear open deck space with side entrances forward of this. In certain cases the pilot house is separated from the engine room and placed amidships forming a covered deck space over the aft portion of the clear deck space. This, however, is in the nature of a minor modification. The illustrations show the features well and should be studied carefully, while the following table gives interesting particulars of small ferries operating in various parts of the country. The stern wheel form of propulsion is very popular on the Western Rivers — in fact, on all shoal draft waterways — this being a copy of the freight and passenger packets similarly equipped. The Diesel engine has proved of great benefit for that work of recent years and even screw shoal draft ferryboats are in operation at the present time.

Froman M. Coots, 350 hp. side wheel ferry, a conversion from steam is one of the most noteworthy electric ferryboats in operation. She links large cities and is therefore of bigger size than the ordinary run of river ferryboat. She preserves the familiar Western River open deck with side doors and wooden rails forward and aft, but has a large superstructure amidships with passenger accommodation. Her length is 172 ft., beam 75 ft., and depth 7 ft. Two 240 b.hp. Diesels drive two 175 kw. generators and supply current to two 175 hp. direct current motors each connected to a side wheel through double reduction gears, giving a paddle speed of 14 r.p.m. Pilot house control is another feature of the installation. *Froman M. Coots* is really a classic motorship and her arrangement takes one back to the early days of Diesel engineering on the Russian rivers, where side wheel tugs were electrically driven in a somewhat similar manner.

This table brings out several interesting points, foremost among which is the popularity of the Diesel engine for such work as this. Its application is not localized or confined to one district, as will be seen, but is universal. It is impossible to generalize on matters

Shoal Draft Ferry Services and Data

Illustration No.	Overall Dimensions Ft.			Propulsion	Power	Type of Mach.	Capacity	Weeks per year operated	District of Operation
	Length	Beam	Depth						
A	108	38	5	Screw	60	Diesel	30 autos	52	Natchez, Miss.
B	64.75	26	3	Stern Wheel	50	Diesel	12 autos 50 pass.	30	Missouri River
C	64.75	26	3.2	Stern Wheel	50	Diesel	11 autos	40	Missouri River
—	68	23.5	7	Screw	100	Diesel	12 autos	52	Lake Pontchartrain *
E	65	30	3	Screw	65	Diesel	15 autos 100 pass.	52	San Joaquin Delta †
F	46	16	—	Screw	62	Gasoline	6 autos	52	Columbia River
G	72	22	—	Screw	45	Diesel	20 autos 150 pass.	52	Escambia Bay, Fla.‡
H	50	25	3	Screw	35	Gasoline	10 autos	52	Waldport, Ore.

* Ship-shape hull: machinery aft. † Double-ender ‡ "Short cut" auto ferry.

of construction since each district has its peculiarities as the illustrations show. Most of the vessels are constructed of wood: many of them according to the whims and fancies of the owner. Dimensions, as will be noticed, are comparatively modest; but even so, it is surprising what a large auto capacity these di-

Western River Ferryboat Types.

Illus. A. Screw Ferry 60 hp.

Illus. B. Sternwheel Ferry 50 hp.

Illus. C. Sternwheel Ferry 50 hp.

River Ferryboat Types.

Illus. E. Broadside view. Double ender.

Illus. E. End on view. Double ender.

Illus. F. Screw Gasoline 35 hp.

mensions incorporate. The phenomenal increase in auto traffic in all parts of the country has given some ferries a new lease of life and has enabled owners to go in for new ships with modern forms of propulsion. It has called other ferries into existence. It is interesting to recall here that even comparatively recently many sternwheel ferries on the rivers were propelled by horses rotating a capstan, which in turn operated the wheel. Thus we could say literally, for tabular purposes, "2 hp": capacity 3 vehicles.

Sternwheel propulsion is popular today for Western River vessels. Elsewhere screw propulsion is adopted and the tendency

Illus. G. Auto Transfer Ferry in Florida. Scow type hull.

is to go in for double ended vessels which are unquestionably more efficient. The danger of exposure to wind and the sweep of the current has been overcome in a very useful manner in Example *F* by building up a breakwater and windshield as shown in the illustration. This boat is a double ender with pilot house and cabin tucked away on one side. In example *H* it is arranged in the center of the deck. This ferry with a length of only 50 feet has a capacity of 10 autos.

For the ferry run between New Orleans, La., and Algiers, it has been found that a vessel of catamaran or double hulled type suits local requirements very well and the type has been adopted. The two hulls are joined by a common deck with vehicular accommodation (side loaded) forward of, alongside on either side,

and abaft a central deck house containing boilers and machinery and having over it a superstructure deck containing passenger quarters. Paddle wheels are arranged aft between the hulls.

Illus. H. Unusual type gasoline ferry. Double ender with central house.

A particular example constructed by the Howard Shipyard and Dock Company in 1925 has the following characteristics:

Catamaran Ferry Characteristics

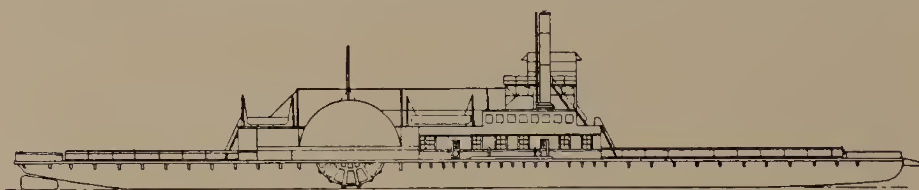
Length overall	150 ft. 6 in.
Length b.p.	144 ft.
Beam at Deck	67 ft.
Beam molded of hulls	18 ft.
Depth molded	9 ft. 6 in.
Draft	5 ft. 6 in.
Displacement (load)	375 tons.
Capacity	70 autos.
	500 pass.
Speed	12 m.p.h.

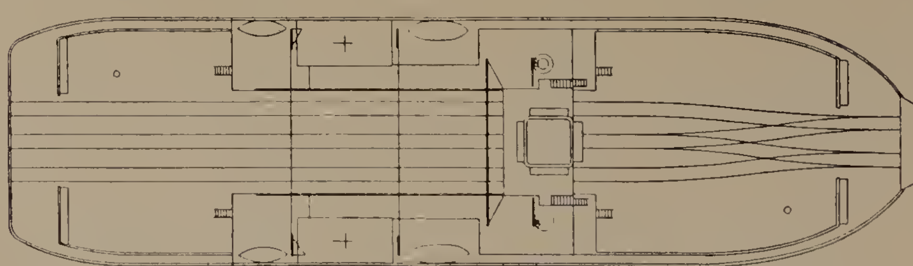
Algiers, as the vessel is named, is probably one of the quaintest vessels, among many of uncommon characteristics, to be found anywhere on the Western Rivers. The type, as far as the author knows, is the only one of its kind in the world.

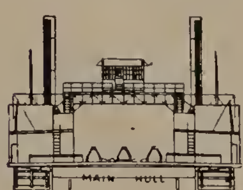
Short Cut Railroad Ferries

Two types of ferryboat have to be dealt with finally, each with characteristics widely differing from the other but both fulfilling fundamentally the same rôle. These are ferries designed to transfer complete passenger trains with their locomotives between two railroad terminals separated by water, where connection from one to the other by land would mean a considerable detour, adding several miles to the journey. The alternative — an expensive one — for a small detour would be a bridge; but this is not always feasible. Certain rivers and bays provide instances of the first type, while on the Great Lakes are found examples of the latter.

The River and Bay Transfer Ferry is merely a large, open car



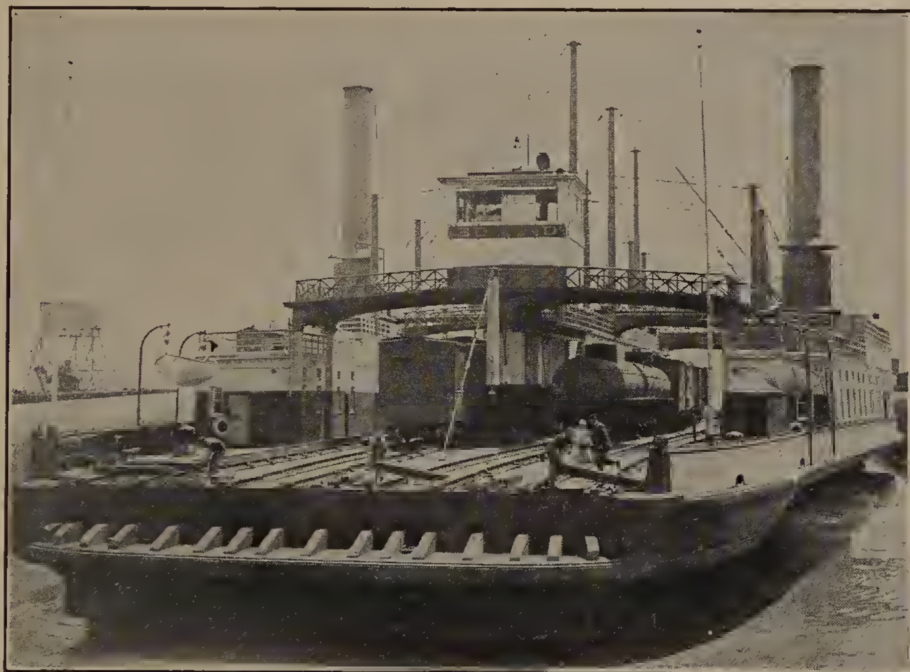




Sketch shows principal features of Big Railroad Ferries.

float with sidewheel propulsion. No passenger accommodation is provided, other than a restaurant and toilets, because usually the run is of short duration. The train is broken up, if necessary, into convenient lengths at one terminal, run on to the ferry, taken across, shunted off, and made up again. It is then ready to proceed. Special switch engines generally handle the train at either end but the locomotive pulls on board the portion to which it is attached. It thus often happens that heavy locomo-

tives stand at opposite corners of the deck, thus subjecting the hull to heavy, twisting strains, which have to be taken care of by exceptionally heavy framing, longitudinal truss girders inter-connected by thwartship diagonals, and transverse bulkheads. Wood,



Southern Pacific R.R. Co.'s big transfer ferry Solano on Carquinez Strait.

as a material of construction for such ships has many advantages and very naturally is used in the West. Here, Southern Pacific Railroad maintains a service across Carquinez Strait between Port Costa and Benicia, Cal., for passenger and freight trains with *Contra Costa*, a 430 ft. wooden sidewheel ferry — probably the largest ferryboat in the world. She is constructed entirely of Oregon pine and cost new (in 1915) $400,000. She makes an average of 46 trips in 24 hours and the trip across takes 8 min. including making fast at each end.

There are four railroad tracks on the deck with 12 ft. centers extending the full length of the ship and giving a total of 1680 ft. of track which allows for accommodation for 36 freight cars and two locomotives, or 17 standard Pullman passenger coaches and three locomotives. The lines of the hull are of scow form;

sides are vertical fairing in from 66 ft. 6 in. beam amidships to 46 ft. at the transoms with an $8\frac{1}{2}$ ft. rise of keel on each end starting at about 35 ft. from the transoms. A superstructure extends 275 ft. fore and aft on each side of the boat and encloses boilers, engineer stands and operating platform; a restaurant and galley; a ladies' lavatory and the usual stores. A pilot house is located on steel bridges which connect the side superstructures at each end of the boat. More than 2,000,000 ft. of lumber were used in the construction of the hull alone.

Four rudders are located at each end of the vessel, made of 4 in. Oregon pine planks with 5 in. diameter forged steel rudder stocks. Owing to the swift current in the Carquinez Straits the

Big gasoline engined Rail car Ferryboat Ramon operates on San Francisco Bay.

vessel is sometimes swept from her course, and the rudders come into collision with submerged rocks, which shear off the plate portion. Consequently a gear is fitted which makes possible easy replacement. To renew a rudder, in the event of damage, ali that is necessary is to remove the tiller arm and a split collar at the top of a cast iron sleeve built into the hull and let the disabled rudder and rudder stock drop overboard. A new rudder is then slipped through the stock sleeve and the split collar and collar arm put on again. This operation takes 30 minutes.

The engines for propulsion consist of two independently operating 2-cylinder simple jet condensing engines (60 in. diameter by 8 ft. stroke) developing 3000 i.hp. at 20 r.p.m., with 60 lb. boiler pressure. The cylinders are arranged one on each side of

the wheelhouse, inclined at 17 deg. to the horizontal. Steam is taken from eight Scotch dry back boilers 11 ft. diameter by 13 ft. long. The boilers are arranged in four units of two.[1]

It will thus be seen that *Contra Costa* is an important unit from constructional as well as from a design point of view. She handles heavy loads and operates an exacting schedule, interruption of which would mean infinite delay to passenger and freight traffic. The attached abstracts from Southern Pacific Lines time table is interesting as indicating the services which the ferry handles. Other ferries handling similar traffic are the *George H. Walker* (340 ft. molded length), a steel vessel with fore and aft truss girders and very rigid construction operating between Anchorage, La., and Baton Rouge, La., on the Mississippi River and owned by the Gulf Coast Lines, New Orleans, Texas and Mexico Railroad, and the *Ste. Genevieve*, connecting the main line of the Missouri-Illinois Railroad across the Mississippi River. Oakland, Antioch and Eastern Railroad operate the gasoline engined ferryboat *Ramon* (236 ft. length overall) on a portion of their routes between San Francisco and Sacramento. This ferry carries electric trains and as will be seen from the illustration, has overhead live rails so that the trains can run directly on to the tracks on her deck.

Carquinez Strait Ferry Example Schedules

Miles	To Portland, Ore.		
0	Lv San Francisco (Market St. Ferry)	7 40	7 40
4	Ar Oakland Pier	7 58	7 58
4	Lv Oakland Pier	8 05	8 05
6	" Oakland (16th Street)	8 11	8 11
9	" Berkeley (University Ave.)	8 19	8 19
15	" Richmond	8 27	8 27
31	" **Port Costa** *Carquinez*	8 55	8 55
32	" **Benicia** *Straits*	9 15	9 15
49	" Suisun-Fairfield	9 38	9 38
68	" Dixon	.....	.....
76	" Davis (*University Farm*)	10 12	10 12
89	Ar Sacramento (*State Capital*)	10 30	.....

Miles	From San Francisco	
28	Lv Vallejo Junction	7 20
29	" Crockett	7 23
31	" **Port Costa** *Carquinez*	8 00
32	" **Benicia** *Straits*	8 00
38	" Goodyear	8 09
40	" Pierce	8 14
42	" Cygnus	8 19
43	" Teal	8 19
45	" Jacksnipe	8 22
49	" Suisun-Fairfield	8 40
52	" Tolenas	8 40
60	" Elmira	9 05
68	" Dixon	9 23
76	" Davis	9 23
89	Ar Sacramento	10 15

[1] See International Marine Engineering, Dec. 1915, for a full description of this interesting ship.

The main line of this railroad operates through the rich farming lands in the deltas of the San Joaquin and Sacramento rivers, and the construction of the railroad over this low-lying country necessitated building many miles of bridges and trestle work. At one point a considerable expanse of water has to be crossed, and the most feasible way for negotiating this stretch is to ferry the trains over on a boat of the type described in order to save a detour.

Comparison Between Great Lakes and "Straits" Rail Transfer Ferries Showing Also Leading Characteristics

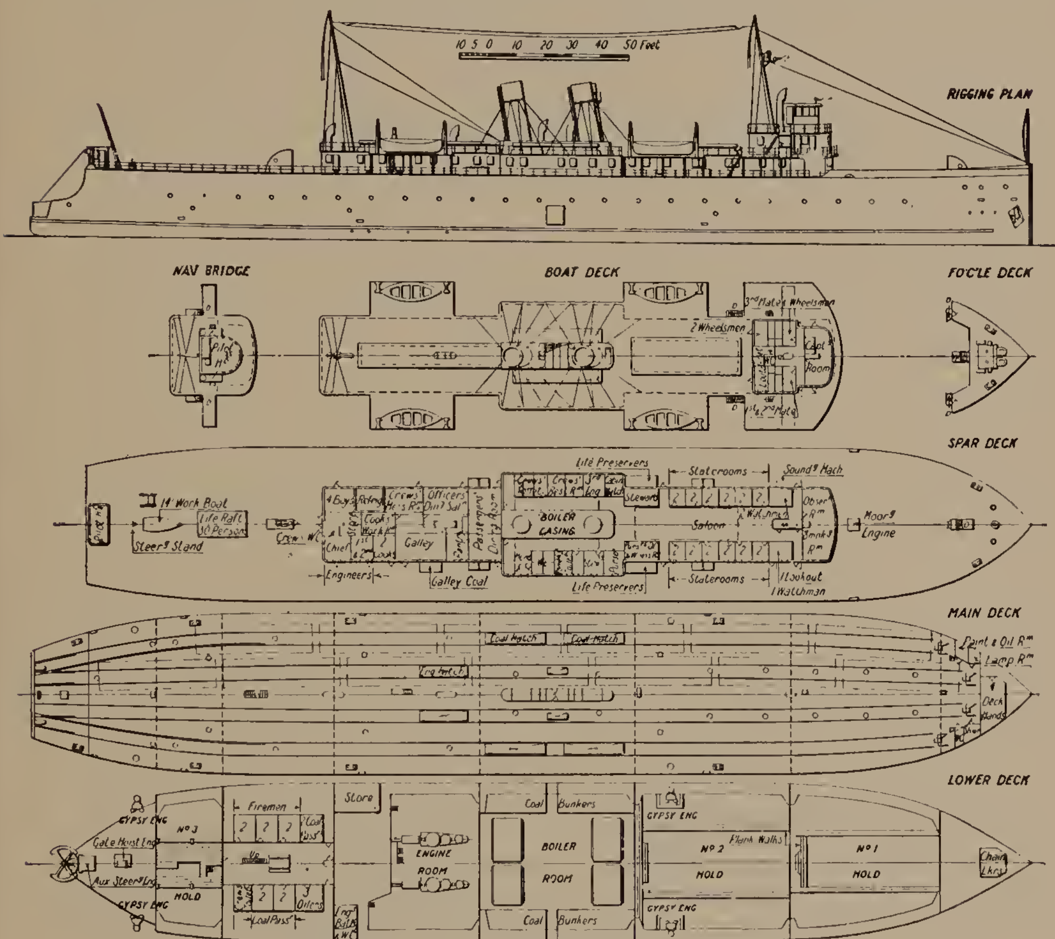
Dimensions		Machinery					Capacity			
							Alternative			
Length Overall	Beam Maximum	Beam Molded	Depth Molded	Propulsion	Power	Remarks	Freight cars	Pullman	Locos	Remarks
433.25	116	66.5	19.5	Side Wheel	3000	Indep't Paddles *	32	17	3	Wooden Hull
340	91.5	56	11	"	1200	" **	25	11	1	Steel Hull
360	56	56	21.5	Twin Screw	2800	Steam Engines	26	—	2	Great Lakes Ferry ***
338	56	56	18.3	"	3000	"	26	—	2	Great Lakes Ferry

* 28 ft. dia. sidewheel. ** 31 ft. dia. sidewheel. *** Maximum depth of hull 38 ft. 10 in.

Great Lakes Transfer Ferries

These, while fulfilling the same function as the vessels above described and while comparable with them from the point of view of size and capacity, form an interesting contrast in their finished arrangement, the main difference being caused almost entirely by weather conditions — ice and cold in winter and open water in summer. This has resulted in a screw propelled vessel, ship-shaped at one end and flat sterned, in order that cars may be run on at this place. The hull really is that of a self-propelling car float, single ended, with the sides extended to a height of about

18 ft. above the main strength deck and covered in, the so-called spar deck thus formed being used for navigating bridge, passenger accommodations, stacks, boats, etc. Cars are loaded and removed from the aft end because the bow must be strong, re-enforced for ice work, and wave-resisting, both of which characteristics



Shows the general arrangement and layout of Great Lakes type Rail Car transfer ferry.

definitely prohibit the use of the "beak," or hinging forecastle, adopted on many Danish rail ferries. Noting these differences and bearing in mind that the strength hull is stiffened in much the same manner, we can make an easy comparison between ships of the *George H. Walker* type and those of the Pere Marquette Railway Co., operating across Michigan between Milwaukee,

Manitowoc, or Kewaunee on the Wisconsin side of the lake, and Ludington on the Michigan side. The drawings herewith based on information published in an article appearing in *Shipbuilding and Shipping Record*, London, Nov. 6, 1924, bring out the characteristics of the Great Lakes car ferries and the table shows how the comparison is justified. It is interesting to see how the beam molded of 56 ft. is maintained in the smaller of the two side-wheeled ferries and in the Great Lakes ferries. There is a similarity also in the other dimensions and in the car capacity.

The spar deck is comparatively a light structure and is not concerned directly in maintaining the strength of the hull, so that this type of ferry has a direct relationship to the passenger and vehicular ferry discussed in the early part of this chapter, as well as to the car transfer ferry, which fact links up the family tree and completes the story as far as this chapter is concerned.

Ferries fundamentally fulfil the same rôle in the scheme of things nautical, and differences are caused merely by local conditions or requirements of service. Apropos of this, the following snappy quotation from a paper — unknown — which has been brought to the author's notice may be reproduced here as indicating the trouble which may arise through a doubtful or incorrect interpretation of the term. The article is an editorial and is here reproduced with full acknowledgments to its unknown source.

"As a result of a rate controversy between two Puget Sound interests, the Washington State Supreme Court will probably be called on to formulate a legal definition of the word, 'ferryboat.' The case is now in the Thurston County court which is expected to give a decision soon. No matter which way the county court decides, an appeal will be taken, it is understood, so that the scope of the word ferryboat will be established in this state for all time.

A decision is certainly needed. Nearly everything that can carry an automobile or other vehicle across Puget Sound or the Strait is now called a ferryboat, regardless of length of the route and other factors. The same looseness of nomenclature is found in other marine terms. For instance, a certain type of steamship

Details of Typical Passenger and Vehicular Ferries

Service or Duty Type	Length (ft.) Beam Mld " Depth " Draft "	Disp. Tons	Capacity	Power Speed Kts	Machinery	Deck Arrangement	Remarks
New York and Staten Is. Cross Bay Double Ended	215 b.p. 218 o.a. 64 ext. 45 19 at side	—	50–60 vehicles 2500 pass	2100 s.hp. 176 r.p.m. 16	Two motors of two speed induction type, taking current from one or two 125 kw D. C. Turbo alternators. 4 coal-fired W.T. Boilers	Two decks. Vehicles on lower deck in 4 asphalt driveways. Passengers in house on top deck.	Hulls built on longitudinal system. Largest type of double ended passenger-vehicular ferry in service on East Coast
Hudson River Cross River Double Ended	131 b.p. 155 o.a. 37 over gds. 48.5 14.25 8.5	500	5 drive-ways	580 s.hp. 180 r.p.m. 13 m.p.h.	One motor of double armature type talking current from two 6-cyl. Diesel 240 kw generators.	Single deck Vehicles only.	First Diesel-electric ferries in New York harbor
Sewall's Pt. Norfolk and Newport News Cross Sound Double Ended	197 o.a. 165.58 b.p. 59.65 ext. 46.65 at deck 15.2 9.25	970	60 vehicles 1000 pass	1150 i.hp. 125 r.p.m. 16	Two 2-cylinder comp. recip. engines 17,34 x 24 in. Two cylindrical boilers 40 ton bunkers.	Two decks. Vehicles on main deck. Passengers on upper deck in house	Separate accommodation for colored passengers on upper deck Lunch Counter.
San Francisco Bay Double Ended	246 o.a. 234 b.p. 44.75 63.5 over guards 19.25 12.3	1340 (load)	80 vehicles 1000 pass	13	One triple exp. recip. 19, 32, 56 × 36 in. taking steam from 3 water tube boilers. Bunker capacity 62 tons.	Two decks. Vehicles on main deck. Passengers on upper deck	Saloon on upper deck contains restaurant, galley, smoking room, ladies' room, main cabin and lavatories.

is called a steam schooner. Looking at one of these vessels, the observer easily can determine where the 'steam' is justified. But he can find no justification for the 'schooner' half of the name. The so-called steam schooner and the real schooner have only one thing in common. Both float. So does a certain soap."

If by any chance the contestants in the above case should feel enlightened after having read this chapter, the author feels that the book will have partially justified its existence.

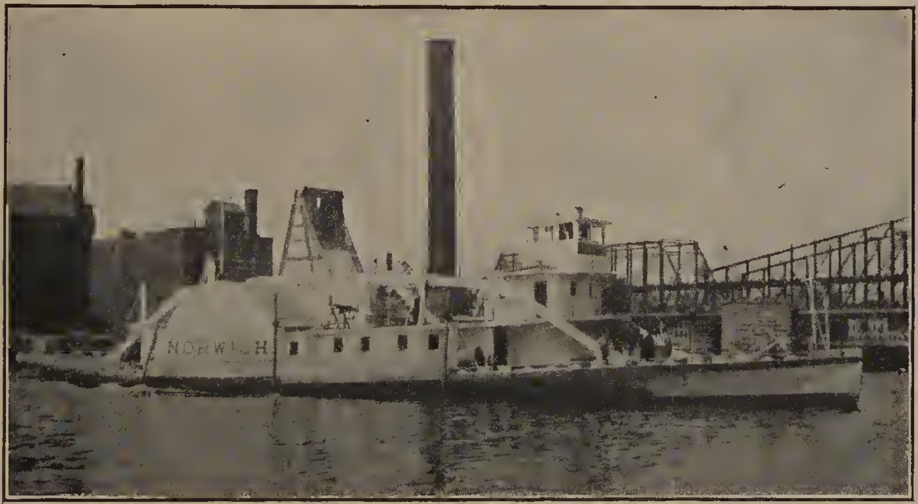
In Europe, ferries of railroad type operate in Denmark, linking railroads on the various islands which go to make up that country, and between Sweden and Germany (Trelleborg–Sassnitz on the Baltic). There is also a freight service between Harwich, England, and Zeebrugge, Belgium, maintained by a British Company, with stern-loading car ferries designed during the European War for cross-Channel transport of locomotives and rolling stock. This service enables freight to be transported by railroad direct from the center of Europe to England without change of car.

The Danish ferries are comparable with the sidewheel river car transfer ferries, although their routes are longer. The Swedish ferries are almost exact replicas of the Great Lakes ferries. It is important to remember these services because, although local conditions differ somewhat, it is often useful in design work to make comparisons with similar craft in other countries. In Europe, all these ships are known as "train ferries," in contrast to the American term "car ferries" or "transfer ferries."

Towboats for Various Duties

Most Numerous and Versatile Ship Type on U. S. Waterways

AN IDEA of the importance of the towboat to American domestic waterways can be obtained from the fact that in the port of New York alone there are always about 700 such vessels in operation, filling requirements of railroads, shipowners, salvage concerns and Hudson River barge owners. In addition



Courtesy G. Rohde, Kingston-on-Hudson.

Norwich, a famous old Hudson River towboat owned by Cornell St. Co., built 1836, broken up 1923, a real old timer 87 years old.

to this fleet, in itself of no mean size, must be considered the fleets operating in the other large harbors on both seaboards as well as upon the Gulf Coast. Nor is the survey complete without account being taken of the numerous pushboats working on the Mississippi, Tennessee, Ohio and other rivers of the Middle West or of the Columbia River towboats and the vessels operating on the waters of Puget Sound.

Local climatic and geographic conditions are responsible for slight differences in design, powering, etc., but otherwise there is a broad similarity between all American sea and harbor towboats, irrespective of their duty, which distinguishes them from similar vessels in any part of the world and which leaves no possible doubt as to the country of their origin. This similarity manifests itself in the long deckhouse, extending for practically two-thirds of the length of the hull, rounded forward, square or round at the aft end and having a height from 8 ft. to 10 ft. The top of this house has a slightly greater length and beam than the house itself and has a tall wheelhouse, rounded at the front and square at the back, at its fore end. Abaft this is the stack, if any, machinery space, skylight, and a boat in chocks. The deckhouse with its wheelhouse is mounted on a strong bluff hull of internationally conventional tug form, having a high block coefficient, and propelled by a large diameter, big pitch, slow running wheel.

Tugs other than American have no long deckhouse except a low machinery casing which varies from 3 ft. to 4 ft. in height according to the size of the boat. Their pilot house, or bridge as it is more generally called, is mounted on a raised portion at the forward end of the machinery casing. Because, in waters other than U. S. domestic waters, towing is seldom done alongside, the towing hook — hooks are generally used rather than bitts — is placed somewhere near amidships, usually abaft the stack. For towing from aft, the ideal position for the towing hook would be the center of lateral resistance of the hull because the pull of the tow rope from this position neither prejudices the movement of the ship nor impedes her steering qualities. If the towing hook or bollard is too far aft, the towboat not only tends to be lifted from the water but also, when the helm is put over she is inclined to be pulled back on her original course. This is a state of affairs existing rather when towboats are handling a large ship in harbor than on long ocean or coastwise tows where the tow is a considerable distance behind the tug. Even so the better position is unquestionably as near midships as possible and prevailing domestic practice, in sea-going tugs, is to arrange an auto-

matic towing winch on the superstructure top just abaft the stack, the tow rope being led over the stern to the tow via a fairlead at the aft end of the deckhouse.

The height of the house still keeps the automatic winch at some distance above the center of lateral resistance but, assuming that the high continuous deckhouse is a *sine qua non* for domestic towboats this position is an effective compromise. Why? For harbor towboats, where towing alongside occupies 90 per cent of their working lives, it is an advantage rather than an encumbrance, forming as it does an effective screen for extremes of weather. It has always been there and designers, following previous ships, have probably never given serious thought to removing it.

There is a distinctly constructive idea in its removal for coastwise service, however, and at the same time arranging the towing winch lower down and fitting large hoops in a thwartship direction over the deck to protect the latter from the whipping effects of tow rope tightening and slacking. A further disadvantage in too much top hamper such as deckhouses is the tendency to raise the center of gravity of the vessel which reduces the metacentric height and is apt to cause the towboat to roll her deck edge under when the helm is put over. In one particular case a towboat had her stability considerably improved by the removal of her steam machinery and boilers and the substitution of a Diesel engine driving the propeller through gearing. The new machinery had a lower center of gravity.

Bearing in mind, then, the features of similarity discussed above we can divide the "genus" towboat into sections as follows:

Seagoing Towboats of between 150 feet and 250 feet in length and up to about 1200 hp. which handle coastwise tows of barges and can if necessary perform long distance ocean towage work, although this latter is virtually a monopoly of Dutch companies.

Harbor Towboats which comprise about 80 per cent of the towboats under the American flag. These are vessels of all sizes up to about 105 ft. in length and 600 hp. Harbor towboats are further subdivisible into *Railroad Tugs* — treated separately— and *General Purpose Tugs* for handling ships, barges, etc., in har-

bors or, to quote one special case, taking barge "trains" up the Hudson River.

Fire Boats which are virtually towboats without towing bitts and with a battery of fire fighting monitors.

Shoal draft Towboats and Pushboats operating on the Mississippi and its tributary rivers and on the Columbia river. These vessels have various systems and combinations for propulsion.

Coastwise tugs are large editions of harbor tugs with bigger all round dimensions and greater power. They have two masts, one forward of the wheelhouse and one abaft the stack in the usual place, and sleeping quarters for the crew — an arrangement not found on all harbor tugs — particularly railroad tugs — because

Powerful coastwise tugs handle all types of craft on long distance tows.

the latter usually only operate on a 12-hour schedule. When they operate on a 24-hour schedule they take on a fresh crew at the end of each 8-hour period. Coastwise tugs are employed in bringing tows of barges from Norfolk and Baltimore to New York and Boston laden with anthracite coal, and returning in ballast. They also tow lumber on the Pacific Coast. This is an easy and economical method of transporting a bulk cargo such as coal for which there is a continuous supply and demand and especially on waterways where navigation is open all year round. On the Great Lakes barge transport of coal would be impracticable because navigation is closed during part of the year and bulk commodities

are required quickly and in very big quantities. This fact has produced the Great Lakes bulk freighter. For coastwise traffic, however, coal can be transported in barges and moved by coastwise tugs with great economy. There is no idle propelling machinery when the barge cargo reaches its destination because when the barges are waiting to be unloaded the "propelling machinery," i.e., the tug, can be employed usefully on other work.

Typical New York harbor towboat handling big Intercoastal motor freighter.

Coastwise tugs are employed also for salvage work and for long distance work and there is generally a small fleet of them attached to every port. Coastwise towing of barges, however, may be said to belong to the Eastern and Gulf Coasts rather than to the West. Conversely, note that harbor tugs on the Western Seaboard, and more particularly those operating in Puget Sound and on the Columbia River specialize in lumber towing.

Harbor tugs handle dump scows within harbor vicinities, move barges and assist large ocean-going ships to berth at their piers. In proportion to the number of tugs employed for this purpose in

other countries, American harbors absorb a smaller number of towboats exclusively for berthing and undocking ships. This is owing to the efficiency of the American pier system of port construction. In Southampton, England, for example, a fleet of railroad owned towboats is maintained exclusively for handling the large transatlantic liners with which New York is so familiar. These have to be made fast to the ship when she is docking in order to *pull* her head or stern round. In New York the incoming ship's head is assisted round by the towboats *pushing* her head at right angles to the direction of her approach upstream and thus gradually getting her alongside the pier. Then, when the ship sails, she backs out from the pier under her own power and is straightened out for down river progress by the aid of her own engines and by tugs pushing the stern round. The harbor tug's work in this case, then, is largely one of pushing and for the purpose large rope fenders are fitted over the nose of the vessel.

In New Orleans, the swift current and strong eddies in the river and the custom of employing only one tug to tow or shift vessels requires very powerful vessels with hulls of not too great size to be handled quickly in the strong currents and counter-currents.

Railroad Tugs

Railroad tugs, such as those used in the harbor of New York, are the most specialized craft of their kind in the world, because although all are designed for towing purposes, various towing duties may be assigned to them. Furthermore owing to the fact that some of the railroads are wealthy compared with private owners, they own larger and more expensively equipped fleets as well as extensive repair shops for keeping these units in first class condition. Specialization of design is possible for this reason, as well as the reason that the peculiar requirements of railroad duties require special tug types. The result is that there are three railroad towboat types — the Drill or shifting tug, the Float tug, and the Transfer tug.

The Drill tug is a small vessel about 75 ft. long and 250 i.hp.[1] which moves barges or carfloats from one berth in a dock to another or to a berth in an adjacent dock.

The Float tug, which group contains practically 80 per cent of all railroad tugs, is a vessel around 100 ft. in length and with about 750 i.hp. She is used in assembling and towing carfloats and barges from a rail terminal to distant piers where freight is unloaded directly from the freight cars on the floats or from the barges which latter for this work are usually of covered type, i.e., virtually freight cars on a barge hull.

The Transfer tug differs slightly in function from the Float tug in that her work comprises the towing or transfer of carfloats from one railroad terminal to another. The freight cars so handled are actually in transit and are not loaded or unloaded at either terminal. Transfer tugs are around 115 ft. in length and have about 900 i.hp. These are really the largest railroad tugs with the possible exception of a few vessels of about 130 ft. designed for long tows in which the tow is handled astern on the end of a tow rope instead of alongside as is always the case with Drill, Float and Transfer tugs. An example of the larger type is to be found in the vessels operating the Norfolk–Cape Charles ferry of the P. R. R. Here, however, it should be noted that the compactness of Diesel-electric drive has enabled the required power to be arranged within the compass of a Transfer tug hull in the case of *Wicomico* which has an overall length of 122 ft. and only 575 s.hp. This vessel went on service in the summer of 1926. The main difference between the largest type of railroad tug and the Transfer tug is the towing engine — usually automatic — and in the arrangement of accommodation, sleeping quarters for the crew being provided on the former and only locker accommodation on the latter.

Railroad tugs operating in harbors are all handled and controlled by a tug despatcher — brother of the train despatcher on shore. This practice, as a matter of fact, has been borrowed and

[1] See "A Diesel Electric Tug" by Frank L. Dubosque, Trans. Soc. Naval Arch. and Marine Engineers, 1924.

adapted by a number of the larger private towboat owners. But the whole question of towboat despatching is now being revolutionized by the adoption of short range wireless telephony to the work. This enables the despatcher to call up any tug within his area quickly and to send it off on another job without requiring its return to tie up and report verbally or by telephone.

The most constructive thought which has yet been expressed in railroad towboat design is that of Pennsylvania R. R. in two Drill tugs constructed in 1926. They were, and still are, unique among tow boats in being double ended, with a propeller and

Pennsylania R. R. Co.'s double ended Drill tugs working in Jersey City slips.

rudder at each end, the propellers being arranged to rotate in opposite directions and the rudders to work together or separately. One 250 hp. double armature electric motor is coupled to both propellers by a straight through line of shafting. The current is supplied to the propelling motor by two 105 kw. generator sets driven by 150 b.hp. Diesels and complete control of the ship is from the pilot house. The novelty lies in the fact that the ships can move in either direction at will with the greatest of ease and without any turning in the slipway. Each rudder is under complete control from the pilot house and can be de-clutched at will after returning to the centerline. Normally, however, the two rudders are in operation which secures a high degree of maneuver-

ing ability. The ships are actually small double ended ferryboats in everything but service. They have an overall strength of 80 ft. and a beam of 19 ft.

Hull Structure

Towboats vary in structural characteristics between the wooden hull type and the steel hull type. The latter may be taken as representative of modern practice, except in districts where lumber is cheap and plentiful and with very small vessels, but because of their stout construction wooden hulls are likely to be in operation for many years to come. A wooden-hulled tug will often outlive many sets of machinery and there is more than one such vessel which has outlasted the change from coal burning to oil burning and from steam to Diesel. One particular example which this remark calls to mind is a railroad towboat aged about twenty years in 1926 when she was converted to geared Diesel drive. As originally designed she had a wooden hull and superstructure, which latter, during construction, was changed to steel. Consequently when finished she had, owing to the extra weight, less freeboard than her designer intended. Couple with this the fact that even more weight was added in 1924 when she was converted from coal to oil burning and it can readily be imagined that a very wet ship resulted. Conversion to geared Diesel drive, with a low center of gravity, in 1926, improved her stability, by increasing the metacentric height, and increased her freeboard due to smaller aggregate weight.

Typical for modern towboat construction, the midship section, studied for detail, shows a bar keel worked in conjunction with ordinary angle iron framing and deep floors, the tops of which are reverse frames to the main frames. It is customary to fit a low bulwark above the sheer strake. The bar keel is continuous all fore and aft being scarphed at the fore end to the stem bar and at the aft end to the stern frame. There appears to be no fixed rule regarding the shape of the stern or the type of rudder selected, some towboats having a semi-balanced rudder while

others have an ordinary plate rudder bringing about the fore end. Stern frame apertures are necessarily large in order to allow for the large pitch, large diameter wheels and they rise at the top at an angle of about 45 deg., fairing into the counter. The bulwark at the stern is vertical in many of the older wooden vessels but in more modern ships it slopes forward at an angle of about 35 deg. A large rise of floor is incorporated with a very rounded bilge and this in association with a slight tumble home gives the midship section an almost semi-circular outline.

The old wooden fender has been replaced in some modern railroad towboats by steel fenders. These consist of a parallel strake or strakes of plating, furnaced to be convex outward from the ship's side, the hollow space so formed being filled with cement in some cases. They are riveted to the sheer strake.

Following are scantlings of a typical harbor tug of recent design:

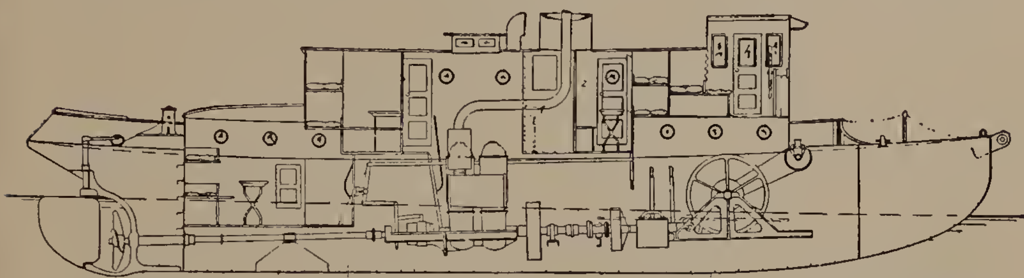
Harbor Towboat Scantlings; 135 ft. x 27 ft. 6 in. x 16 ft. 3 in. reg. dims.

Item	Scantlings	Remarks
Stem bar	6 in. × 2 in.	20 in. scarph to keel
Stern post	6½ in. × 3½ in.	Scarphed to keel
Bar keel	6 in. × 2 in.	
Rudder stock	6½ in. dia.	
Frames	6 in. × 3 in. × 12.75 lb.	Spaced 22 in. center to center.
Reverse frames	3 in. × 3 in. × 7.2 lb.	Across top of floors.
Reverse frames in machinery space	3 in. × 3 in. × 7.2 lb.	Double
Deck beams	6 in. × 3 in. × 12.75 lb.	Bulb bars on every frame
Floors	30 in. deep	In machinery space with center keelson between frames.
Bulkhead	4 in. × 3 in. × 8.5 lb.	Single angles
Boundary bars	3½ in. × 3 in. × 7.9 lb.	Angles
Bulwark	12.75 lb. plating	2 ft. high

Log Towing and Winding Boats

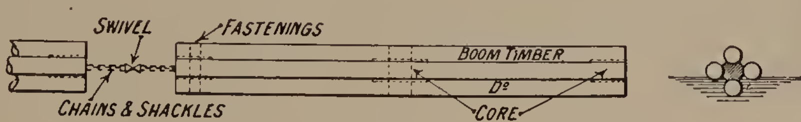
In Eastern Canada, handling of long tows of lumber has produced a special type of towboat known as the "winding boat." This is really an ordinary towboat equipped with two lots of ma-

chinery, one for propulsion and the other for winding. The latter is used in the following way: the vessel proceeds about 1½ miles ahead of her tow, and drops her anchor, the cable running out over a special roller arrangement in the bow. She then turns and reels out her cable until she arrives back at her tow. Fastening



Special log winding towboat used in Eastern Canada designed by W. A. Lambert, Montreal.

on to her tow of logs by a short stout line, she winds in the cable by means of the roller arrangement operated by the winding engine. This operation takes both towboat and tow to her anchor, and consecutive operations of this nature move the tow along at a fair rate. The lumber, as shown in the sketch herewith, is made up into booms composed of four logs, with a central core bolted as shown, and connected at the ends of each series by swivels. A 100 b.hp. winding boat, operating her winding engine, took 120,000 logs 18 ft. long by 6 in. diameter, aggregating over 1,000,000 ft. of timber, a distance of 9 miles in open lake water



Make-up of Eastern Canadian lumber boom.

at an inclusive speed of about 1 m.p.h.[1] At another time she took 90,000 logs about 30 miles, working on her propeller alone, at the rate of 0.75 m.p.h.

On the Pacific Northwest coast lumber is handled in a different manner and [2] harbor tugs of this district of which oil-engined craft

[1] See Shipbuilding and Shipping Record, London, Sept. 3, 1925.

[2] See an article entitled "Towing Log Booms with Small Motor Tugs" in *Motorship*, June, 1925.

now form a large proportion, have probably the heaviest tows of any of their class to handle as a steady pull. The ordinary harbor tow, consisting of vessels, barges or scows, when once started moves along readily at a speed of from 3 to 6 knots, but the booms of logs cut from the exceptionally heavy timber of the western slopes of the Pacific Coast ranges tax the little craft severely, because 1½ to 2 knots is about the best speed that can be made with the average boom.

Booms are usually made up between sticks held in position by

Pacific Coast lumber boom being handled by a small tug in Vancouver harbor.

rows of piles about 60 ft. apart, though some booms are made as wide as 80 ft. The logs are floated in between the boom sticks and packed as tight as they will fit, in order to tow end on. A "swifter" log is then hauled across the top of the boom by a donkey engine and securely chained to the boom sticks at either side. Swifters are placed at intervals of 50 or 60 ft., corresponding with the length of the boom sticks on either side. The number of sections in the boom is counted by these swifter sticks, and

while the number of feet (board measure) to the section varies according to the size of the logs, about 40,000 ft. b.m. of logs to the section is regarded as a fair average.

Large tugs bring booms of 25 to 50 sections down the coast, and in many cases give them to small harbor towboats for distribution to the mills in tows of 10 to 20 sections, for convenience in taking them through bridges and yarding into the mill booming grounds, where the water is often too shallow for the larger tugs to work.

Propelling Machinery

The universal instrument for propulsion for the towboats discussed in the foregoing pages is the screw. The sidewheel has now gone entirely out of use in American waters. The screw is a large diameter large pitch unit of cast iron or manganese bronze turning at a slow rate of revolutions per minute. This is translated into figures in the following examples:

Towboat Propeller Details

Engine Power	Max r.p.m.	Diameter	Pitch	Material
575 s.hp......	125.........	9 ft. 6 in.......	9 ft. 6 in......	Bronze
360 b.hp......	102.........	8 ft. 0 in.......	10 ft. 6 in......	Bronze
250 b.hp......	125.........	7 ft. 8 in.......	10 ft. 6 in......	Cast iron

The r.p.m. listed above represent the average maximum r.p.m. when running free but they serve to show the characteristics of the propulsive element and to introduce a discussion as to the different types of propelling machinery at present available for towboat propulsion. The oldest and most conservative form of propulsion is the compound non-condensing steam engine and cylindrical boiler or the slightly less inefficient compound condensing steam engine and cylindrical boiler. Both of these combinations for American towboats may be regarded as obsolescent and their place is being taken gradually by some form of Diesel propulsion. This does not mean, of course, that the steam towboat

will vanish in a night, because owners cannot afford suddenly to scrap them. Rather is it a question of the gradual attrition of the steam tug by replacements either by entirely new tonnage or by substitution of Diesel for steam machinery when the latter becomes worn out in a sea-and-weatherworthy hull. In 1926 for example one prominent railroad had the whole of its steam driven fleet — not only towboats but also ferryboats and other craft — comprising over 300 units, scheduled for conversion in units, when in each vessel the steam machinery and boilers needed serious overhaul. In the same year also, a prominent New York towboat owner admitted to the author that the steam driven towboat was obsolete and stated that he thought the process of change would be a gradual one occupying in the case of New York about fifty years. He owned at that time one Diesel tug but intended to convert as occasion demanded.

This condemnation of the steam towboat may seem rather sweeping but it is justified by a consideration of the characteristic advantages of the Diesel towboat. Stated briefly, these are as follows:

Lower fuel consumption
Larger fuel capacity for the same size of hull
Less time taken to take fuel on board
Smaller crew required.

With a coal fired steam tug, fuelling occupies about three hours in every 48, while with the Diesel installation only four to five hours every two or three weeks are so occupied. Much valuable time is also lost with the steam tug of non-condensing type in proceeding frequently to a water plug to "croton up" [1] or fill with water, or to remove ashes.

The Diesel gives a constant pull with its constant power, while the pulling power of the steam tug is in the hands of the steam pressure which, in turn, varies directly as the ability and energy of the firemen.

Standby losses are eliminated entirely with Diesel tug, and

[1] Term used in New York, the operation being named for Croton Reservoir, Westchester Co., N. Y.

with a ship operating a 12-hour schedule 12 hours standby fuel is saved which would be expended by the steamer. This is important when it is considered that there are so many tugs which tie up at night. With the Diesel, the crew can come down on board in the morning and start up right away.

A smaller crew is required for the motor tug which assists the lower operating costs.

Most of the above points are well known and generally accepted but they are not always realized. Against Diesels for propulsion, it is urged that the initial cost is greater, that they are not reliable, that they demand a higher standard of intelligence for operation, and that they run normally at too many revolutions per minute for the slow running propeller necessary for towboat work.

Initial cost is higher because the purchaser is paying for a superior article. In any case this is soon offset by the lower operating costs. Furthermore the greater the number of Diesel engined tugs placed in service, the cheaper will they tend to become as manufacturers are encouraged to produce on a mass basis. Unreliability is a many headed bogey which common sense and knowledge should long ago have killed. A certain amount of doubt as to reliability has been justified by the indifferent performance of a few badly designed engines and by the indifferent handling of a few good engines. The bad engines have been gradually forced off the market while the good engines have now proved their merits through intelligent handling. The Diesel does demand a higher standard of intelligence in the engine room personnel but this is only in accord with the general higher demand for intelligence in the marine engineering profession. It is essentially a young, keen man's job, and the towboat which is handled by a disgruntled steam engineer, whose bible is the reciprocating steam engine, can never be a success. Fortunately, this spirit is not very prevalent.

The question of co-relating propeller revolutions with those of the fast running Diesel is one which can be solved in one of two ways, or left unsolved. In the latter case a straight drive is

employed and the slight disadvantages of unsuitable speeds are left to adjust themselves. The solution lies in placing between the fast running Diesel and the slow running propeller some form of speed reduction gearing — either mechanical or electrical. This permits of quick unwavering pilot house control and exact adjustment of the revolutions of propeller and prime mover, reduces the amount of slip registered if the Diesel is direct connected to the propeller, but is more costly. Direct connection means either a direct reversible Diesel or a lever operated clutch which latter is hardly feasible in engines of over 300 b.hp. Assuming, however, an engine which will operate well ahead or astern and maneuver quickly there seems to be no reason why the direct Diesel drive should not compete successfully with indirect forms especially for towboats of the Transfer type which do not require so much maneuvering as, say, a Drill tug. It is unquestionable that the propeller of big diameter and pitch does not operate at best efficiency when coupled to a fast running Diesel, but in any case, the loss is not excessive as working examples have proved. The large wheel is always urged as a necessity by towboat operators to "bite" the water for heavy pulls. It is possible, however, that propeller experts may show us that a smaller wheel will give equally good results, for, after all propeller research is still in its infancy. Showing that thought is being given to this idea, a recent direct coupled Diesel installation on a towboat has a propeller 7 ft. 6 in. diameter by 5 ft. 9 in. pitch compared with a 9 ft. 0 in. diameter by 12 ft. 3 in. pitch wheel on a corresponding steam tug, and a 9 ft. 6 in. diameter by 9 ft. 4 in. pitch wheel on a Diesel-electric tug.

Direct Diesel drive requires a considerably larger air supply for maneuvering than does a Diesel-electric or mechanical geared tug where maneuvering is carried out by friction clutches on the gears and the prime mover is uni-directional in its rotation. This points to the advantage for direct drive work of some form of 2-cycle airless injection engine driving its own maneuvering air compressor.

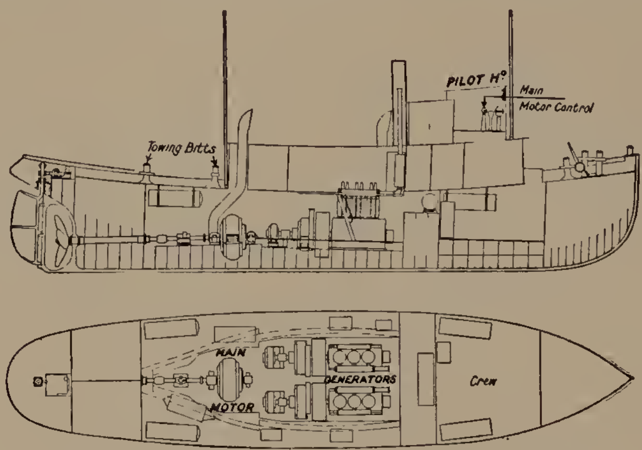
Towboat engines receive and execute more maneuvering signals

per hour than the machinery of practically any other type of ship one can think of, although ferryboats in some cases compete very hard for second place. Among towboats, the harbor towboat and in particular the railroad Drill and Float tug are maneuvered particularly hard. Frank L. DuBosque of the Pennsylvania R.R. gives an average number of 566 signals per 8 hour watch for several Float tugs, or one order every 51 sec. Orders are still, in many tugs, transmitted from the pilot house to the engineer by means of a bell. Time is, however, inevitably lost in the execution of the order even if the engineer is highly skilled in maneuvering, and this has caused towboat operators to look with favor upon pilot house control whereby the pilot himself has absolute and direct control of the prime mover operating the propeller from a standard alongside the steering wheel. With electric drive this is an exceedingly simple matter, in fact it would seem strange to arrange otherwise, although of course the precaution is taken of duplicating the control in the engine room. Electric control allows a 250 hp. motor to be put from 125 r.p.m. ahead to 125 r.p.m. astern in 6 sec. This is ideal for Drill tug work.

With direct Diesel drive, pilot house control can be arranged fairly simply by extending the engine controls, which should be as free from complications as possible, to the pilot house by means of levers and bell cranks — not always a satisfactory arrangement — while with the Falk geared drive, where control is carried out by disc friction clutches operated by oil pressure, a dual system of control must be arranged for regulating the engine speed and for controlling the pump which puts oil pressure on the friction discs, throwing the propeller in or out of action as required. Controls fitted in the majority of vessels are externally close copies of stereotyped engine room telegraph standards. This serves the useful purpose of familiarizing the system to operators.

For Diesel-electric drive the arrangement of machinery is simple. One or two Diesels coupled to generators and exciters with necessary auxiliaries, starting air bottles, etc., are arranged at the forward end of the engine room, while at the aft end is situated the main propelling motor, switchboard, with emergency

controls, and the principal ship auxiliaries such as bilge and ballast pumps and fire pump. In most modern tugs electric steering gear is fitted, the steering wheel operating a motor which drives a quadrant on the rudder head. Sometimes an hydraulic ram type steering gear is fixed on the aft engine room bulkhead, controlling



Diesel-electric towboat with General Electric equipment.

the tiller through wire ropes and chains. In other cases, this is arranged aft, while in others it has remote control but is on the main deck in the engine casing. Following is a table giving capacities and powers of machinery for typical electrically driven towboats.

Typical Electric Towboat Propulsion Equipment

Length of ship	105 ft.	108 ft.	97 ft.
No. of Diesel Generators	2	2	2
Cycle	4	4	4
Cylinders	6	6	3
Diesel power per unit	400	400	225
Generator output	235 kw.	270 kw.	—
Main motor power	575	650	370
R.p.m.	125	120	120

The other system of indirect drive mentioned above in which mechanical gearing is controlled by means of disc friction clutches has, as far as the Diesel is concerned, the same advantages as

electric transmission, i.e., the prime mover can be of non-reversible type and can run during the whole time the tug is in operation without starting and stopping. It is necessary, however, as has been explained, to provide on the control means for increasing or decreasing the speed of the engine as well as of throwing it in and out of operation. The Falk reduction gearing system does these two things combining the Metten patent friction clutch and Falk-Bibby flexible couplings. Its working is best explained by referring to the figured diagram shown below. This drive was first applied in 1925 to Cornell Steamboat Co.'s tug *Cornell* whose duties comprise assembling barge tows at stake boats in New York harbor prior to their movement in "trains" up the Hudson River to Albany. New York Central Railroad towboats Nos. 21 and 22 were converted from oil burning boiler and steam reciprocating layouts to this form of drive in the summer of 1926.

The main — or speed reduction — drive is at the propeller end and consists of a set of double helical gears. The two single spiral gears between engine shaft and clutches serve as reversing mechanism and are practically even gears with a hunting tooth.

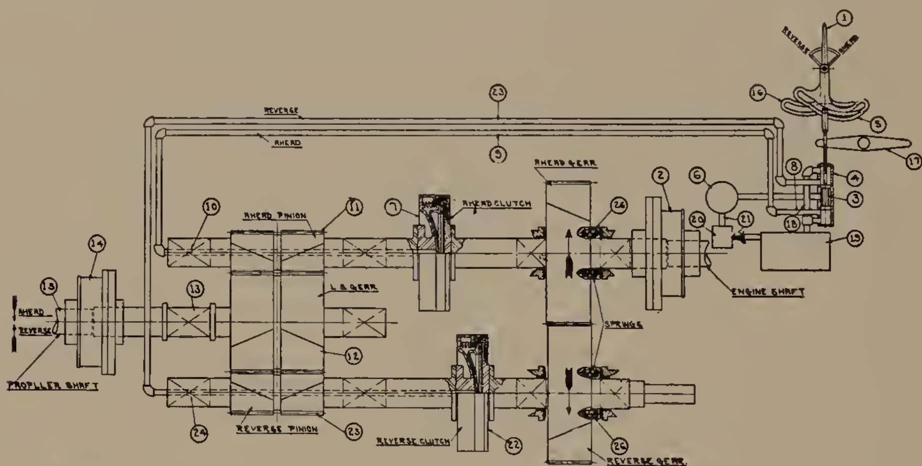
When the operating lever *1* is in the vertical position as shown on the diagram, both clutches are disengaged, and the engine, which is connected by means of a Falk-Bibby flexible coupling *2* with the upper gear shaft, runs idle, turning the reversing gears, but leaving the reduction gears and propeller shaft at rest.

Upon the order to go ahead, the operating lever is moved to the ahead position and piston *3* inside the clutch control valve *4* is caused to move down by action of the cam *5*, thus establishing a direct connection between the oil pressure tank *6* and the clutch *7* through the pipe lines *8* and *9* and the hollow shaft *10* forcing the clutch to engage. The engine torque is then transmitted through the clutch *7* and the pinion *11* to the main driving gear *12*. Gear shaft *13* being connected by means of another Falk-Bibby flexible coupling *14* to the propeller shaft *15*, a direct connection is established between the engine and the propeller, causing the boat to go ahead at the instant the clutch engages.

While only a slight shifting of the operating lever suffices to

force the clutch engagement, further movement of this lever accelerates the engine speed gradually by means of the engine cam *16* and the fuel control lever *17*, until maximum propeller speed is obtained.

Upon the signal to stop, the operating lever is thrust back into the vertical or neutral position. Consequently, the piston *3* connected with the cam *5* rises and cuts off the oil pressure from



Clutch control gearing used on towboat Cornell between main engine and propeller.

tank *6* and pipe lines *8* and *9* to the clutch *7*. The pressure release causes some of the oil in this system to drain through the by-pass pipe *18* into the sump tank *19*. The result is that clutch *7* disengages, thereby breaking the clutch connection between engine and propeller shaft. Engine and reversing gears then turn idly and the propeller stops rotating.

A pump *20* transfers the oil from the sump tank *19* through the pipe lines *21* to the pressure tank *5*.

Suppose the order is given to reverse. The operating lever is then thrown in astern position. Valve piston *3* rises and establishes direct communication between the pressure tank *6* and the clutch *22* by means of pipe line *23* and the bore through the shaft *24*. The oil pressure then compels the lower clutch to engage, so that the power is transmitted from the engine through the reversing gears and pinion *25* to the main driving gear *12*, thereby operating the propeller in the opposite direction.

The time required to throw the drive from full ahead to full astern is about 2 sec.

Engagement and disengagement of clutches requires a slight axial movement of the reversing gears and their shafts. The single spiral reversing gears, in conjunction with the extensible Falk-Bibby flexible coupling, make such an end movement possible. The clutches are so constructed that upon their engagement the respective reversing gear and shaft move about $\frac{3}{32}$ in. forward, compressing springs *26*. Upon clutch release the action of these springs forces the gears and shaft back into their original position.

Movement of lever *1* into the first notch on either side of the neutral position completes the engagement of the respective clutch and ensures the continuation of the drive ahead or astern, as the case may be. Further movement of this lever in either direction accelerates the engine speed gradually, by means of the engine cam *16* and fuel control lever *17*, until maximum speed in either direction of rotation of the main propeller is obtained. The further away from neutral position the lever is moved the more fuel is admitted into the cylinders and the greater is the speed of the engine.

A 4-cylinder oil pump *20* (which will also be noted in the illustration of the engine control) furnishes pressure for the system, and relief valves on both the clutch pressure lines get rid of excess pressure on the sump. Two Falk-Bibby flexible couplings, *2* and *14* in the diagram, are included in the system, and these permit operation with the shaft of the helical gears or of the engine as much as 3 deg. out of line. The clutches themselves, shown diagrammatically in part section, were designed by W. Metten, chief engineer of the Cramp Ship & Engine Bldg. Co. They consist of fibre and steel discs pressed together by oil pressure led in through the hollow shafting.

The oil in the clutch control system is at 80 lb. pressure. The total pressure required to grip the discs is 25 tons.

Summing up, then, we find that there are three main choices of drive in the application of Diesel to towboats:

1. Direct Drive
2. Indirect (mechanical) drive
3. Indirect (electrical) drive

All of these can be arranged to operate with pilot house control but no. 3 is best adapted to this purpose. No. 3 may require more skilled attention than the other two, but it is remarkably efficient where heavy maneuvering is required, and for this reason is specially suited to railroad work. American towboat owners were among the first to realize the advantages of the Diesel engine to their work, and especially the advantages of electric. Many U. S. tugs now in commission are the most modern and efficient in the world. European tug owners may well learn a lesson from their transatlantic contemporaries.

Fire Boats

The only excuse for including fireboats in this chapter is the fact that their general dimensions and hull lines closely resemble those of an harbor towboat although their powering and internal arrangement is different. The fireboat is a self-propelling hull of towboat form containing powerful pumps drawing from the surrounding water and discharging streams of water through strategically mounted monitors. As with the towboat, the Diesel engine has now practically replaced steam both for propulsive and pump operating purposes, Diesel electric drive being particularly suitable for the work. Fireboats can tow but because their propulsive equipment is provided mainly with the object of securing rapid transit from one point to another, the same considerations regarding large diameter wheels do not hold, and many fireboats are twin and even triple screw. Some vessels have Diesels for main propulsion and Diesels or Diesel generators to supply power or current for operating the main fire pumps. Other vessels have one or two main sets of Diesel generators supplying current to propelling motors and to pump motors.

The vessel whose general arrangement plan is reproduced, with acknowledgments to *Marine Engineering and Shipping Age,* on

one particular unit of the former group, is powered by seven 300 hp. and two 25 hp. gasoline engines. Three of the seven units drive a centerline and two wing propellers, the two wing engines driving also pumps and being so arranged that they can rotate the propellers when the vessel is proceeding to a fire and the pumps when the scene of a fire has been reached. The remaining four engines are direct connected to pumps. The center engine is available for maneuvering when the vessel is operating her pumps.

Nozzle capacity of 8300 gal. of water per minute is registered by this powerful fireboat.

The six pumps each have a capacity of 1700 gallons per minute at 200 lbs. discharge pressure, giving a total delivery of 10,200 gallons per minute. The fireboat which has a length between perpendiculars of 93 feet 4 inches has a service speed of 17 miles per hour.

A larger vessel — 125 ft. 10 in. in length b.p. — has two 350 kw. Diesel generators supplying current for two 360 hp. propulsion motors and two 410 hp. fire pump motors. There are five nozzles with a total capacity of 8300 gal. per min.

River Pushboats and Packet Boats

Are Shoal Draft Craft with Ingenious Design Characteristics

THE great rivers of the midwestern plain — the Ohio, Mississippi and Missouri, and other allied waterways require a special type of towboat to carry out a special type of work. The large waterways and rivers of the West, such as the Columbia River and parts of Puget Sound use also similar vessels. As far as the midwestern rivers are concerned, however, the title "towboat" is a misnomer because "towing" in the accepted sense of the term does not exist and "pushing" is in nearly every case substituted for it. That is to say the vessel containing the prime mover, i.e., the "pushboat" places itself behind the scows or barges to be moved and literally pushes them along. These barges are fastened end to end in a practically rigid manner with the result that a "push" of 6 coal barges forms a continuous river ship about 400 ft. in length carrying just over 5000 tons of coal with the barges arranged in pairs side-by-side and the push boat astern. A good modern type of barge employed in this work is usually of box type about 135 ft. x 26 ft. x 8 ft. and carries about 660 tons, and trains of barges of this type are employed in carrying coal to the furnaces of the Pittsburg steel district. In passing, note that tows of coal from Germany along the European inland waterways to Dutch ports comprise four or five large "Rhine ships" having a total capacity of about 5000 tons towed behind a tug. In both cases the cargo carried is equivalent to the capacity of a small sea-going freighter.

A train of barges with an overall length (including that of the pushboat) of over 400 ft. is quite a big proposition, and in order to reduce length, a six barge tow may sometimes have its members

arranged three abreast, or the pushboat with two barges directly ahead and the four others *en echelon* on either side. This makes a compact arrangement. Pushing is a necessity on the Western Rivers owing to the width of stream, the very sharp bends, and

The business (forward) end of a pushboat showing squared off deck edge and capstans.

the sweep of the current, all of which would render ordinary "towing" an impossibility. The unit containing the prime mover and the units containing the freight must form a compact whole which can maneuver as a whole and which can flank readily — i.e., nose round a bend by putting the pushboat's head towards the bank and backing on the sternwheel.[1] Pushboating is in some ways comparable to carfloat and scow towing alongside practiced in most of the big harbors.

[1] See "Transportation on Inland Waterways" by Brig. General T. A Ashburn, U.S. Army. Trans. Soc. Naval Architect and Marine Engineers, 1925.

Ability to flank a tow, embracing handiness in steering, flexibility of machinery and reserve of power is but one requirement of design. With it must be combined a draft not exceeding, in the more severe cases, 5–6 ft. (parts of the rivers would not be navigable at all during the summer season were it not for canalization) great longitudinal strength and strength to stand running aground frequently without any damage to the hull structure, and in this already restricted hull space to carry sufficient stores and fuel for a protracted run (e.g., St. Louis–New Orleans), in addition to accommodations for a full crew.

SHOAL DRAFT PUSHBOAT PARTICULARS

Hull Dimensions. Ft.					Hull Form				
Length o.a....	200	175	126	85.2	No. of superstructure decks.......	1	2	1	1
Length b.p....	—	150	—	70					
Beam molded .	40	32	26	17	Shape of Bow .	Pointed	Scow	Pointed	Pointed
Depth molded.	10	6	7	5	Shape of Stern.	Square	Overhang	Square	Overhang
Draft	6	4.5	4.9	2.5	No. of Rudders	4	3	4	2
					Material......	Steel	Steel	Steel	Steel

SHOAL DRAFT PUSHBOAT PROPULSION

Power developed.	900 i.hp	400 i.hp	520 b.hp	100 s, hp
Engines.........	Triple exp	Horiz	Diesel	Electric
No. of units.....	2	2	2	1
Propelling agent.	Screw (tunnel)	Wheel	Screw tunnel	Wheel
Drive...........	Direct	Pitman	Direct	Belt

Types of Pushboat

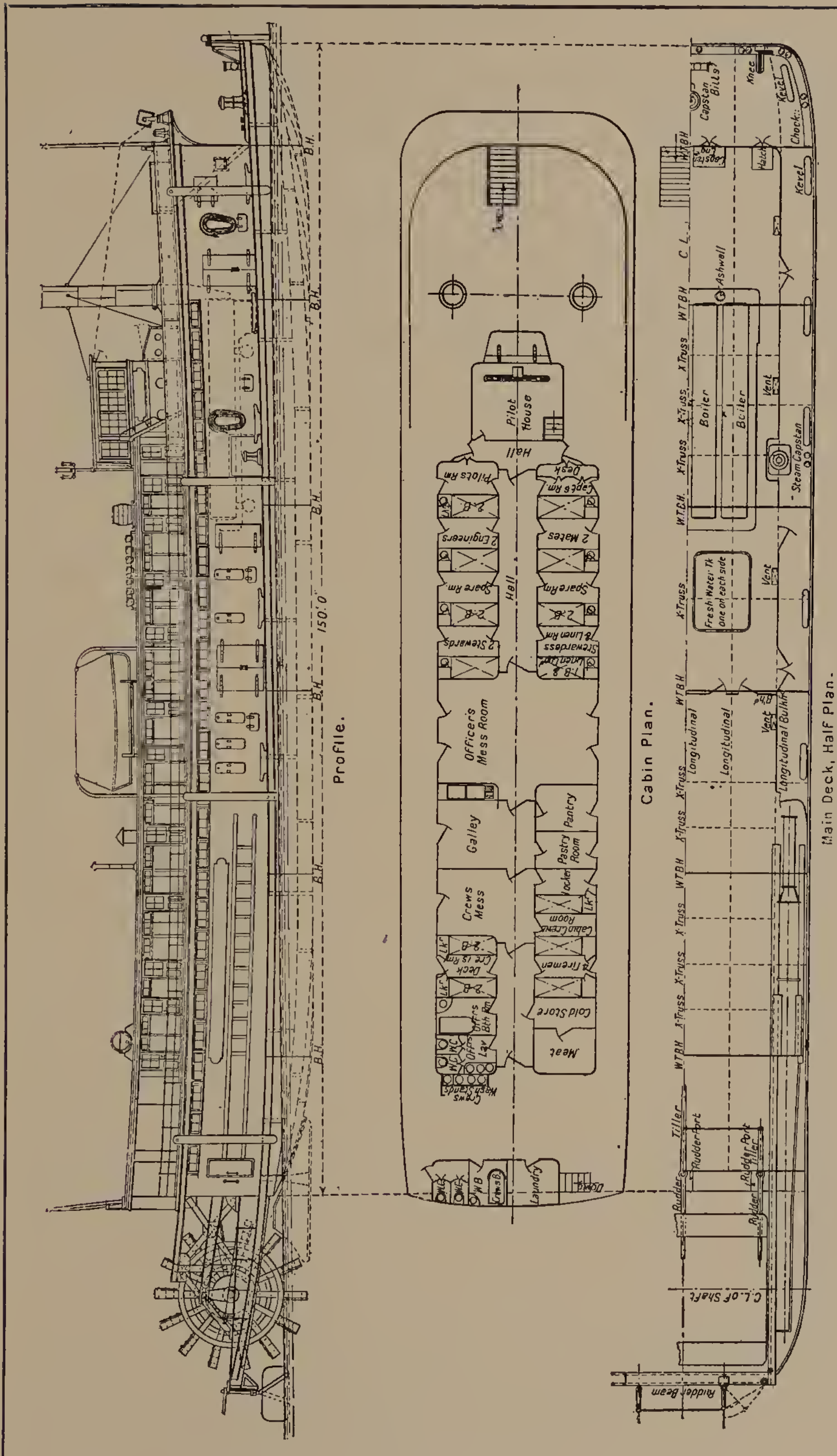
The above table shows particulars of and characteristics of recent pushboats whose design may be taken as typical of modern practice. A change has come over the construction and arrangement of pushboats within the last few years largely brought about by the use of steel as a material of construction and to a certain extent owing to the adoption of the Diesel engine, in direct or in-

Diesel propelled pushboat "pushing" 6 barge loads of coal in Pittsburg district. The sternwheeler is at the rear end of the "push."

direct form, for propulsion. Both these tend to make for compactness and the modern push-boat has a much more snappy, if less picturesque, appearance than her predecessors constructed entirely of wood. A disadvantage of the wooden hull is that it becomes waterlogged as it gets older, weighs heavier and hence draws more water. In many districts the steel hull costs more to build but is stronger and has a longer life.

The same general characteristics apply to all pushboats operating on the Western Rivers. Minor differences of detail occur with vessels for different owners, and of size for different services. The modern pushboat has a shoal draft hull with considerable parallel middle body, slightly rounded bilges, no rise of floor and no tumble home. On the contrary, some pushboats maintain a distinctly flared midship section. Forward, the lines fair into an easy fore body the bow in some cases being of normal ship-shape form without the flare and with a rising forefoot and in others of scow form. Shape of stern depends upon the type of propulsion adopted — screw or sternwheel. Screw pushboats have tunnel sterns and the stern contour is flat, while sternwheelers have an easy scow type stern on to which is built a structure for holding the sternwheel itself and two or more of the rudders.

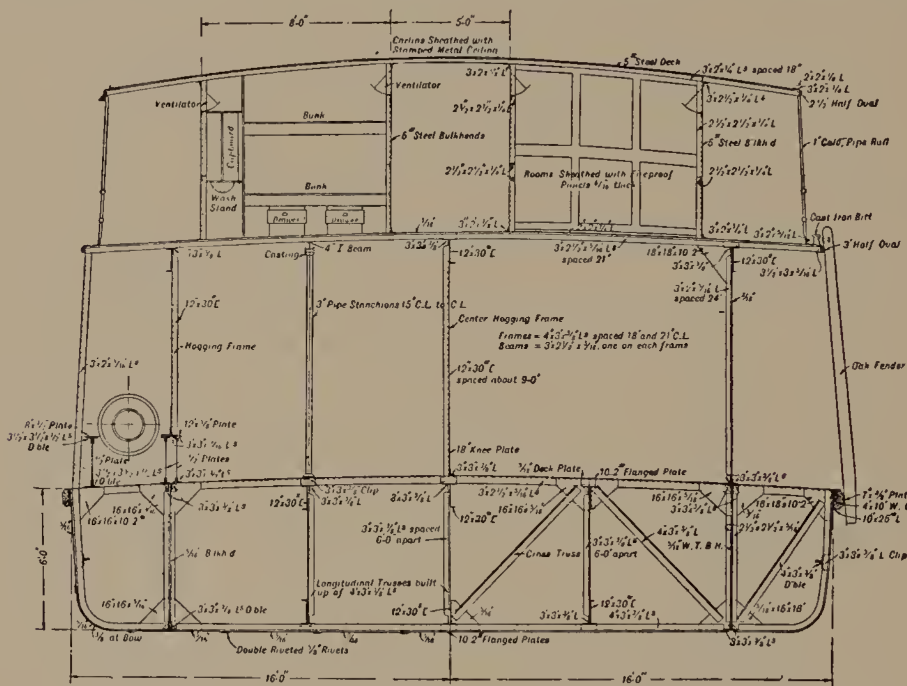
Except in a few special cases, no double bottom is fitted and the machinery rests directly on the hull bottom, stiffened in that vicinity by heavy channel bar framing, or *on* the deck of the main hull structure. For example, a pushboat with molded beam of 26 ft. a molded depth of 5 ft. 6 in. and machinery *in* the hull structure has her bottom framing in way of machinery of 7 in. x 9¾ in. channel beams which run across the ship to the turn of the bilge. These bars are absolutely flat, there being no rise of floor, and they are not joggled, the necessary joggling being carried out in the shell plating. The propelling machinery is mounted on fore and aft girders resting on the transverse channels. Longitudinal strength is given to the hull structure mainly in way of the machinery space by two strong fore and aft truss girders similar in construction to those used in conjunction with ferryboats. These fore and aft girders are worked at the inner ends of



A large Western River pushboat with a semblance of old time arrangement. Ship has pitman drive to sternwheel from main engines.

the 5 in. x $6\frac{1}{2}$ in. channel beams, cut in way of the machinery space, and are connected to them. Forward and aft of the machinery space the framing is of frame and reverse frame type.

A pushboat of 32 ft. beam molded and 6 ft. molded depth with her machinery on deck has frames of 4 in. x 3 in. x $\frac{3}{8}$ in. angle. There are three longitudinal trusses one on the centerline and one on either side and two longitudinal side bulkheads forming wing



HALF CROSS SECTION AT ENGINES LOOKING FORWARD HALF MIDSHIP CROSS SECTION SHOWING CROSS TRUSS

Midship section of pushboat with engines arranged on the hull.

tanks for a portion of the length. These truss girders are made up of 3 in. x 3 in. x $\frac{3}{8}$ in. in angle spaced 6 ft. and connected by diagonals in a fore and aft as well as in a 'thwartship direction. All diagonals are attached to top and bottom of the hull structure by 12 inch channel bars and this construction in conjunction with pillaring and trussing of the upper structure makes a strong job capable of standing severe longitudinal or transverse as well as twisting strains. Of course the greater amount of material worked into the hull the greater the weight and hence draft, so the secret of successful design consists in knowing just how much strength to give the vessel for the work she will have to do.

An example in which great strength was secured and a double bottom fitted, at a certain cost in draft, however, is found in the *Natchez* class of twin screw river pushboats designed for work on the Mississippi between St. Louis and New Orleans. These six ships represent some of the finest examples of ships in service on the Western Rivers and are masterpieces of careful design. Built to be operated by the Inland Waterways Corporation, they have an overall length of 200 ft., a beam molded of 40 ft., a depth molded of 10 ft., and a draft of 6 ft.

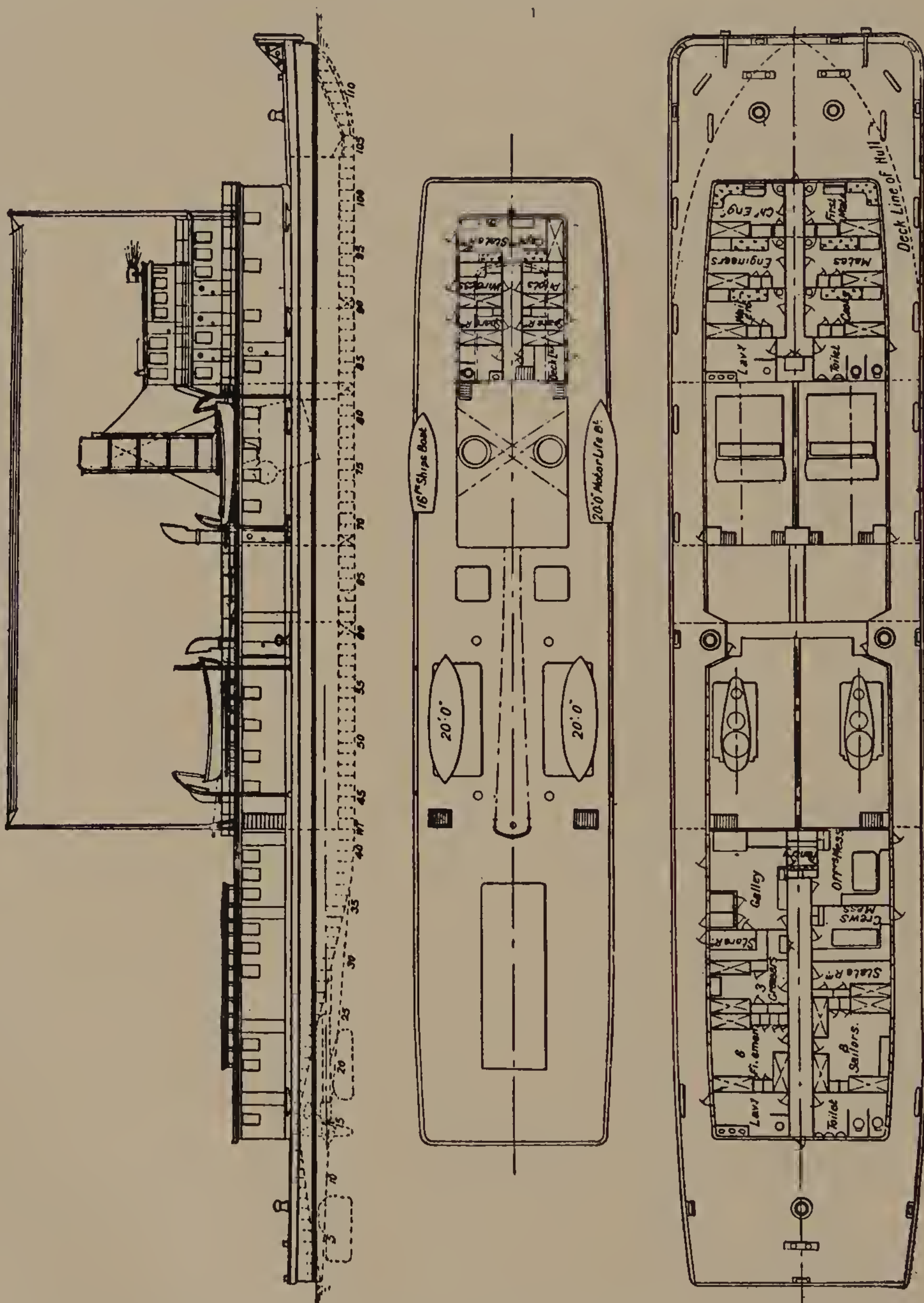
They are fitted with a continuous deck house about 150 ft. long, an upper deck house about 30 ft. long, and a pilot house above the upper house about 20 ft. long. The main deck house is arranged to accommodate crew, greasers and firemen, stewards, galley, mess-rooms, laundry, lavatories, fuel tanks and machinery spaces. The upper house accommodates the pilot, wireless operators, and engineers, there are also spare rooms, lavatories, officers' saloon and deck lockers. The pilot house has the forward part raised to give the helmsman a clear view in all directions. This house affords accommodation for the captain, with enclosed stairs to the lower house. Quarters are provided for a total complement of 30 men. Capstans and heavy bitts and cleats are provided to facilitate the handling of barges in all positions.

Double bottoms are fitted under the engine and boiler rooms for fresh water. The fresh water capacity is about 100 tons. Oil fuel is carried in tank compartments, one between engine and boiler room extending to the upper deck, and the other forward of the boiler room extending to the main deck. The total fuel capacity is about 335 tons.

For ease in handling, four rudders are provided in accordance with general practice for this class of work.

The lines show a flat section with slightly rounded bilges worked into an easy fore-body, and tunnel arrangement aft. There is no sheer except at the ends.

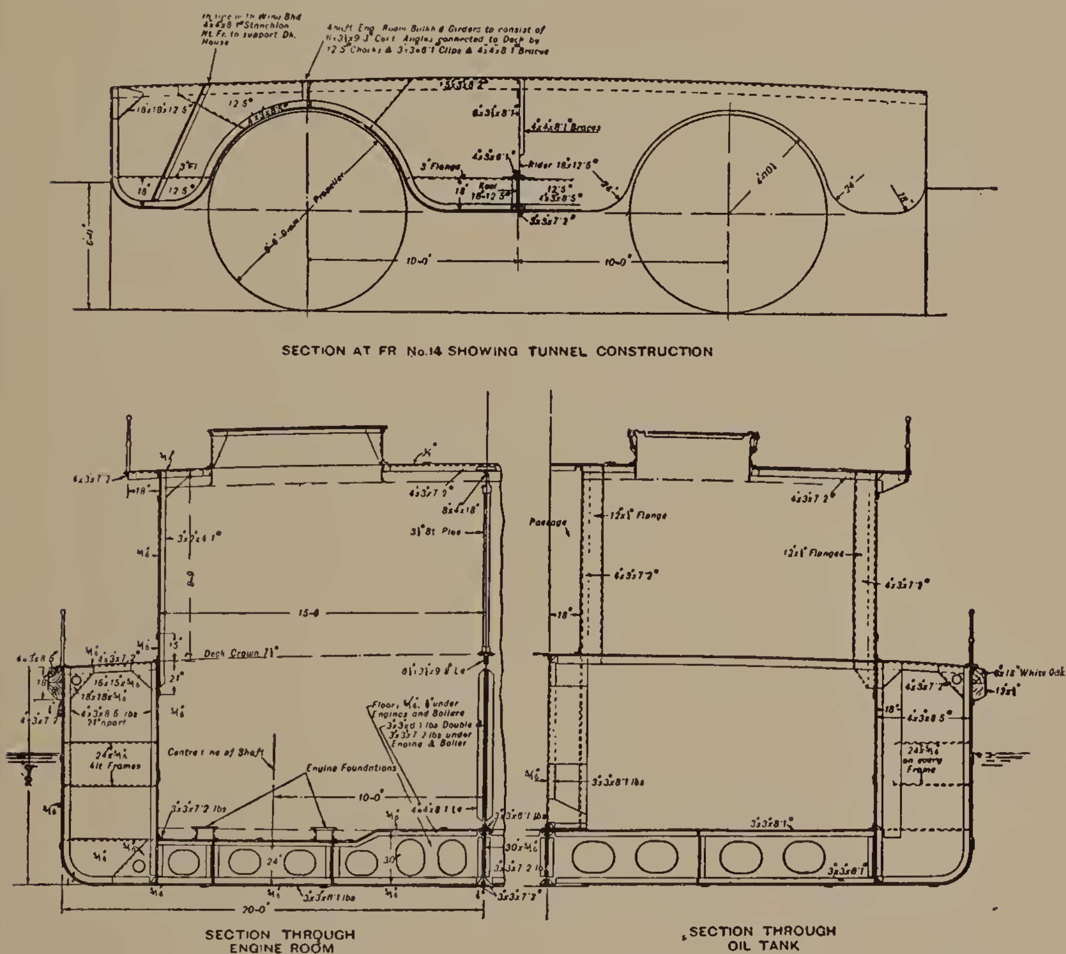
Special fenders are rigged at the bow to give a bearing for pushing barges, either light or loaded, without danger of their ends fouling under the overhanging deck.



Acknowledgments to Shipbuilding and Shipping Record.

Big Mississippi pushboats of Natchez class with 1800 hp. operate long haul loads between St. Louis and New Orleans.

The propelling machinery consists of two triple-expansion engines with cylinders $15\frac{1}{2}$ in., 25 in., 44 in., × 26 in. stroke, developing about 900 i.hp. each. There is one surface condenser of 2,400 sq. ft. cooling surface. Two oil fired water-tube boilers have a total heating surface of about 8,000 sq. ft. working at 250 lb. per sq. in. pressure. There are the usual auxiliaries, all independent.



Sections through Natchez class pushboats show double bottom and tunnel stern construction.

There are two generating sets, 10 and 5 kw. respectively, 110 volts, direct connected, steam driven, built to operate at 80 lb. steam pressure, non-condensing.

In 1926 four of the *Natchez* class towboats operated with three barges upstream from New Orleans to St. Louis. Each barge

loaded to about 2000 tons on its designed draft, but in periods of low water this loading sometimes had to be reduced. These tows operated on a schedule which averaged 265 hrs. from New Orleans to St. Louis and 108 hrs. southbound.

The remaining two towboats were reserved for the handling of tows of bulk cargoes, which could not operate on such a fast schedule as the regular tow. These tows consisted of not less than five barges and sometimes as high as seven or eight barges if cargo offered. The bulk cargoes were chiefly grain, bauxite and sugar, and their respective tonnages during the fiscal years ending June 30th, 1924 and 1925, were as follow:

Bulk Cargoes in Long Tons

COMMODITY	1924	1925
Grain	220,652 tons	261,227 tons
Bauxite	143,762 tons	174,966 tons
Sugar	121,878 tons	156,897 tons

Grain is downstream and the other two commodities move upstream.

Modern machinery and modern steel construction are tending slowly to eliminate the old type Western River pushboat with elaborate superstructure, ornate pilot houses and tall twin stacks and this is particularly noticeable in the case of the vessels illustrated in these pages, some of the large vessels shown having a distinctly snappy, sea-going appearance while the smaller ships resemble floating steel sheds. This characteristic is particularly noticeable in the case of *Kosmortar* in which a two-story house is mounted on a shallow screw-propelled hull. The tunnel screw vessel certainly lacks the picturesque effect of her sternwheel driven opposite number, but modern practice tends towards increase of power and simplicity of construction with the elimination of wood in the structure.

Strictly, though this applies rather to the wooden vessels and to the sternwheelers, there are two general structural groups in which Western River pushboats may be placed — the pool boat and the full roofed type. Pool boats are smaller than full roofed boats and derive their name from the fact that their pilot house

is down on the boiler deck in front of the cabin, which allows the boat to go under most bridges. The full roofed vessel has her pilot house on top of the highest deck and this gives the pilot a clear view fore and aft, but restricts her from navigating certain bridges.

The majority of large old time full roofed and pool pushboats in service lend themselves to easy conversion into freighters and

Modern construction and machinery results in workmanlike pushboats of this type.

even to passenger packet boats. In fact many passenger packets can do duty as pushboats if necessary. Passengers can be carried in the superstructure deck and freight on the main deck being side loaded into the open space between the boilers forward and the engines aft and incidentally showing once more the same characteristic as is found in coastwise, bay, and sound transportation, viz., the carrying of cargo *on* the main strength deck, with light superstructure above. This arrangement in Western River pushboats is a direct legacy from the grand old river days of the nineteenth century. The barge, a comparatively new comer, and the self-propelling barge freighter have turned the packet boat into a pushboat; railroads have made the carriage of passengers in large quantities, except for excursion purposes, unprofitable and unnecessary; modern Diesel machinery taking up less

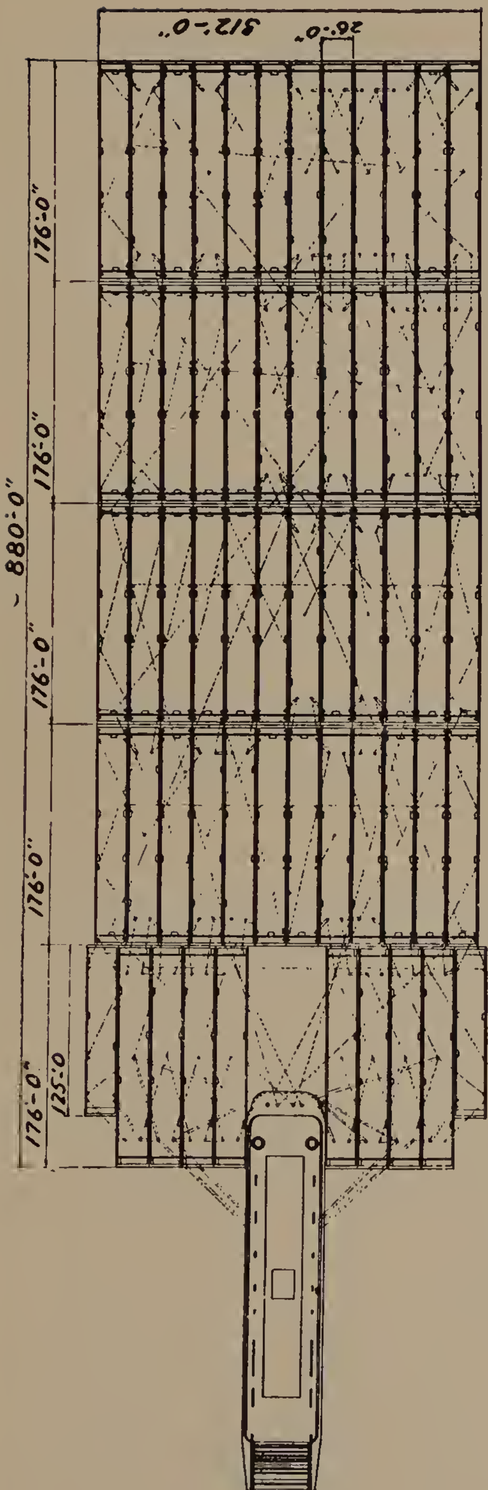
space has permitted the elimination of the superstructure deck by arranging the accommodations in the now useless cargo space, and the result is the modern pushboat — low in aesthetics but high in operating efficiency.

Screw or Stern Wheel?

Having first introduced the modern pushboat, it becomes necessary now to discuss the agents employed for propulsion, and the type and arrangement of machinery in the ship. For the former there is a choice of paddle or side wheel, stern wheel or screw; for the latter the choice lies between steam and Diesel.

Diesel driven pushboat and packet boat for Western River Service.

The side wheel is practically ruled out of account except for a few paddle passenger packets, so the battle is between stern wheel and screw, both of which have their advantages and disadvantages. The stern wheel is a legacy from the old days of river navigation and was ideally suited to the old form of pitman drive through horizontal steam engines taking steam from Western River type boilers. It is not inherently suited to the superior economy of modern fast running prime movers of steam reciprocating or Diesel type and some form of transmission or transmission reduction gear must always be incorporated between prime mover and stern wheel, thus unavoidably lessening the overall mechanical efficiency. This suggests the replacement of stern wheels by screws. But the screw *per se* has certain disadvantages



Plan view diagram shows a 2000 hp. pushboat handling 56 coal barges and 2 oil barges — truly a record "push."

just as the stern wheel *per se* has advantages notably in backing and flanking a heavy tow. It has an even greater turning power if the stern wheel is split, i.e., divided into two separately operating halves.

The necessity for large flanking power is well illustrated in the case shown on this page where a tow, or rather "push" of 56 coal barges and two fuel barges is drawn attached to the 2000 i.hp. pushboat *Sprague* owned by Standard Oil Company of Louisiana. This vessel has a wheel 37 ft. in diameter and 40 ft. in width operating at 11 r.p.m., and it can easily be realized that she has enormous flanking power. A screw vessel of similar power would require very special arrangements to handle such a tow.

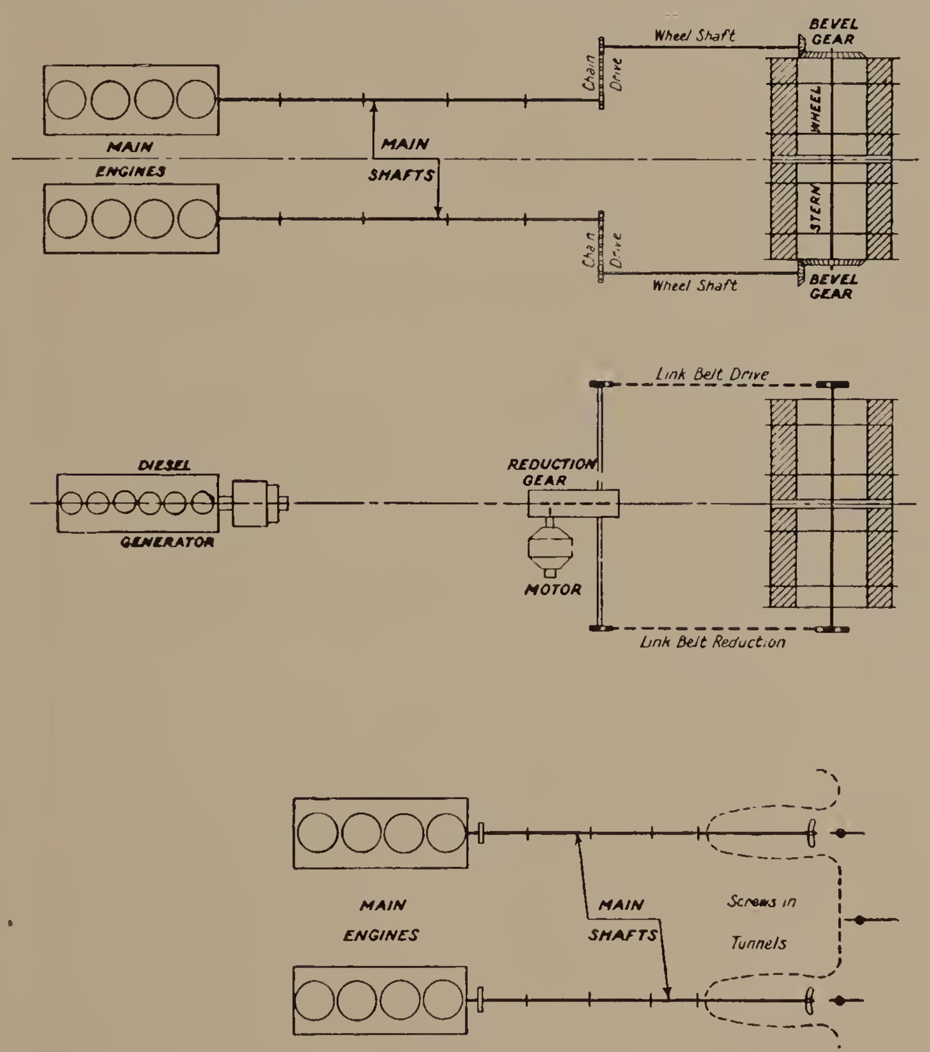
Another factor limiting the use of the screw on Western River packets is the always shoal and generally variable depth of water, factors which make it extremely difficult to get the best performance out of

a propeller. This may be overcome to a great extent by the use of tunnels in which the screw can work in water under practically all conditions and to a certain extent overcomes the danger of damage due to striking snags. If a stern wheel strikes a snag or ice, repair is easy; with a screw it is a more difficult and expensive matter. It certainly is true that the screw pushboat derives considerable flanking and turning power from the fact that her rudders are behind the screws and get the full benefit of the stream flow from the latter but even so their superiority is doubtful over the stern wheel for large "pushes" of barges. It is perhaps indicative of the general realization of this fact that so many screw vessels are being built for smaller tows — chiefly on the canalized portions of the Ohio River. Canalization of the rivers will limit the number of barge units per "push" to the size of the smallest lock, will assure an even, suitable depth of water at all seasons, and will go a long way towards the replacement and even elimination of the stern wheel. Meanwhile it remains, a heritage from the past, useful and eminently practicable but not directly adaptable to modern machinery. Exactly how such prime movers are arranged we are now in a position to discuss.

Machinery Arrangements

The old Western River pushboat belonged to the steam and coal age; the new vessel belongs to the oil age — the age of the Diesel and of the high pressure, high superheat, oil fired boiler. Very little improvement has been made in the application of steam engines to stern wheel drive, but considerable improvements in fuel consumption, operating costs and standby losses have been effected by the application of Diesel drive to stern wheels and it seems probable that this type of prime mover will eventually monopolize Western River craft of the future. Diesels can be coupled to a propeller direct or through the medium of reduction gearing with ease and they can be arranged aft, forward, or amidships, as required, the usual place being just forward of midships, but when it is a question of driving a horizontal thwartships operating unit (the wheel) — by means of a vertical fore and aft

high speed unit, the question takes on another aspect and many ingenious methods have been devised to overcome the difficulty. Two problems have to be faced, viz., how to arrange the drive with least loss in efficiency and how to correlate the slow running



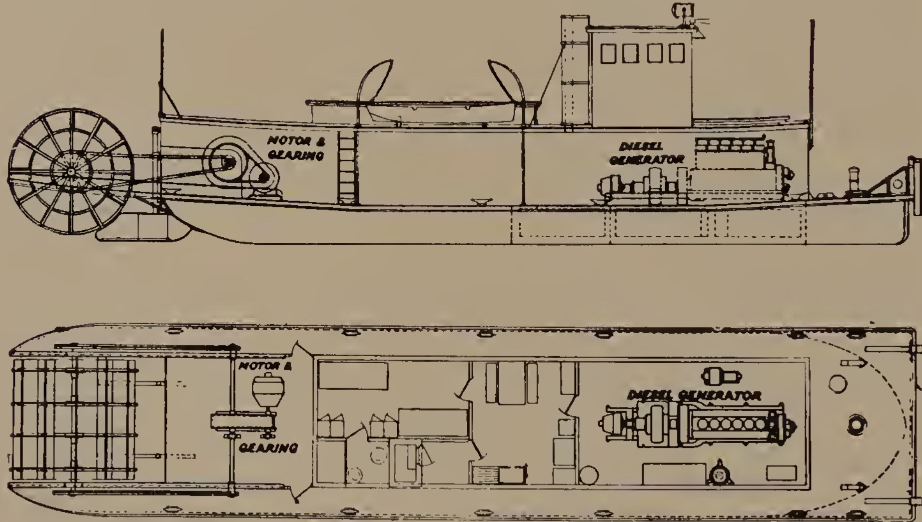
Sketch shows different machinery layouts for Western River pushboats.

stern wheel with the fast running Diesel. The solution lies in a combination transmission and reduction gear and the following arrangements have been successfully tried out on modern pushboats now in service.

Electric transmission comprises a Diesel Engine driving a generator and exciter and supplies current to an electric motor which drives the stern wheel either through belt and reduction gearing

Types of Prime Mover	*Total Power*	*No. of Units*	*R.P.M. Units*	*R.P.M. Wheel*	*R.P.M. Screw*
Steam, high speed recip.	1800 i.hp.	2	120	—	120
Steam, tandem comp.	800 i.hp.	2	20	20	—
Diesel, vertical 2-cycle.	700 b.hp.	2	250	—	250
Diesel, vertical 2-cycle.	400 b.hp.	2	250	23	—

or through the conventional pitman used on the majority of Western River steam packets. Electric drive has the great advantage of flexibility and of eliminating lengths of shafting running along the main deck but it has the mechanical disadvantage

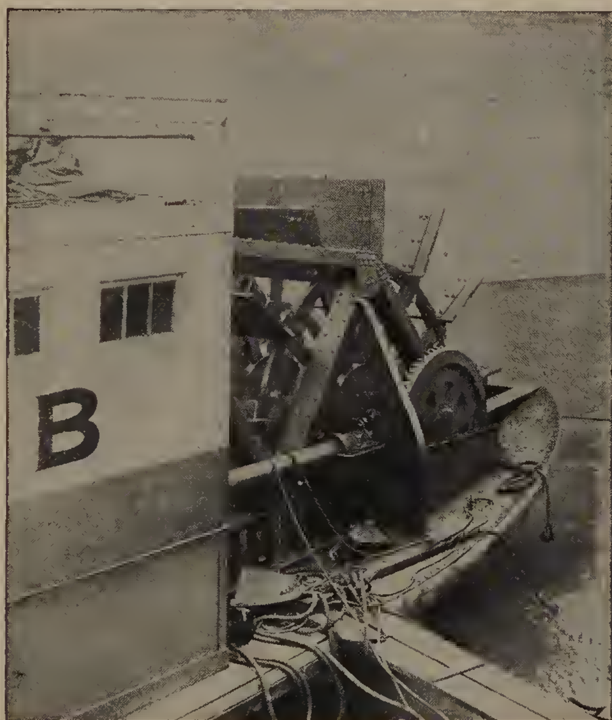


Diesel-electric pushboat showing generator sets and arrangement of propelling motor and gearing on the deck of the hull.

that the motor itself requires gearing and other devices to connect it to the stern wheel. In the particular case shown on this page, a 100 s.hp. shunt wound motor drives a transverse shaft through gearing having a reduction ratio of 4.67 to 1. The shaft is connected to the stern wheel by means of Link Belt drive on either side.

Mechanical transmission from prime mover to stern wheel may

be carried out in a variety of ways, but in nearly every case the actual drive on the wheel is by bevel gearing arranged as drawn in the illustration shown on page 183. A horizontal fore and aft shaft on either side has a small gear wheel cut to engage with a further wheel on a horizontal thwartship shaft which is the axis of the stern wheel itself. The horizontal fore and aft shafts run parallel to the centerline of the ship at a further distance out than the main engine shafting. This is necessarily so because of the



Bevel gear drive to pushboat's sternwheel.

width of the stern wheel. The engine shafts are coupled up to the wheel shafts usually through some form of reducing medium either straight mechanical or through belting. There are two reductions of speed — one at the end of the engine shaft and the other at the bevel gearing. To see what this means in actual figures we may consider the case of a 113 ft. pushboat built in 1925.

The propelling machinery consists of two Worthington 4-cyl-

inder, airless-injection, direct-reversible, Diesel engines, of 120 hp. each at 375 revolutions per minute. Line shafts run aft from each engine to a point about 10 feet forward of the stern where a sprocket-wheel, having three teeth abreast, drives a triple-strand 2 in. pitch roller-chain. The chain, in turn, through a sprocket-gear, drives a fore and aft outboard shaft at from 74 to 78 revolutions and this shaft, in turn, through bevel gears, operates the stern paddle wheel at about 19 turns per minute. Sprockets have 13 and 64 teeth. Bevel gears have 17 and 67 teeth. There are no clutches or gear shifts used externally to the engines, and such devices are rendered unnecessary by the ease with which the oil engines can be maneuvered.

The paddle wheel is divided in two parts so that the starboard engine drives the starboard portion and the port engine the port portion. By this arrangement, efficient maneuvering can be accomplished with half the power and also, if necessary, the boat can be operated with one engine. The paddle wheel has a diameter of 15 ft. 4 in. There are 15 buckets, 8 ft. 4 in. long, with a 20 in. face on each wheel.

In fairness to the tunnel stern pushboat it must be conceded that this arrangement, efficient though it is in operation, means inevitably a loss of mechanical efficiency on account of bearings and gear drives. The great length of main engine shafting in proportion to the length of ship — far greater than in the case of an ordinary ship — must inevitably have bearings throughout its length which we can call loss no. 1. Loss no. 2 comes in the drive to the outboard shaft with its step down in speed of rotation. Loss no. 3 occurs at the bevel gearing with its further step down in speed. Electric transmission involves only losses nos. 2 and 3, while the straight drive to a tunnel propeller means loss no. 1 only. In the sternwheeler, loss no. 1 cannot be obviated by placing the engines nearer amidships because of the already existing heavy weight aft due to the shafts, gears, sternwheel and its built out housing. The screw pushboat has her engines nearer amidships and, in order to effect a straight through transmission, *in* the hull instead of *on* the deck.

Columbia River Towboats

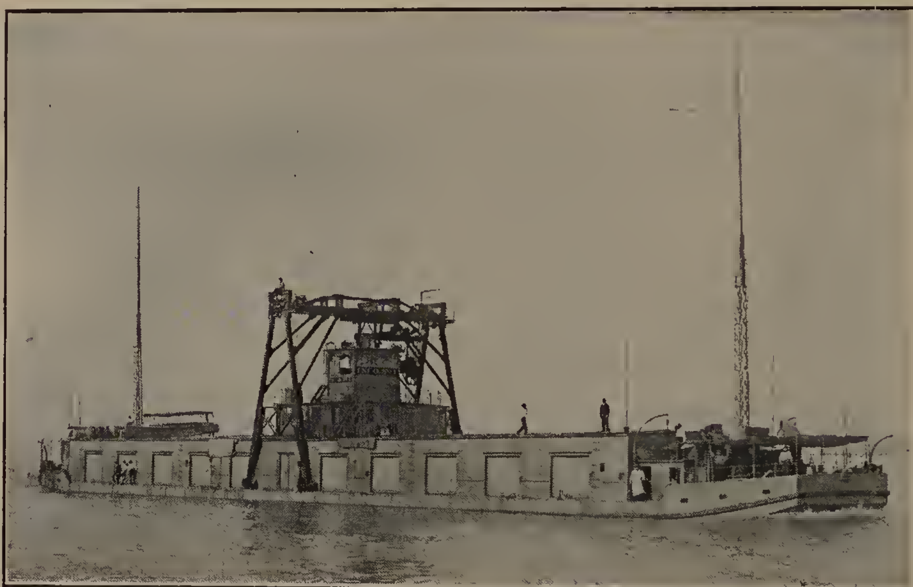
The Columbia River type of shoal draft sternwheeler resembles the older Western River pushboats in general characteristics having the same long shallow hull and box superstructure containing engines, boilers, and cargo space. On the top of this is a superstructure containing accommodation and having above it at its forward end a small house with pilot accommodation and a pilot

Columbia River towboat which had her stern and sternwheel removed and screws, in tunnels, substituted.

house above this again. The main difference from Western River practice is to be found in the bow arrangement which is of ship-shape form with the deck shaped to the natural run of the hull and not projecting and square ended as is the case with Western River boats, shown in example on page 169. Here the main deck is square ended and has two large, vertical wooden post fenders suitable for pushing. This also shows two electric capstans used for pulling in the barges into the pushboat hull. Columbia River towboats do not push barges but are employed in moving ocean-going ships in harbors, and in log towing on the shallow rivers. The sternwheel is gradually being replaced by the tunnel stern with screws both in new construction and in some existing vessels which are converted.

Other Western River Ships

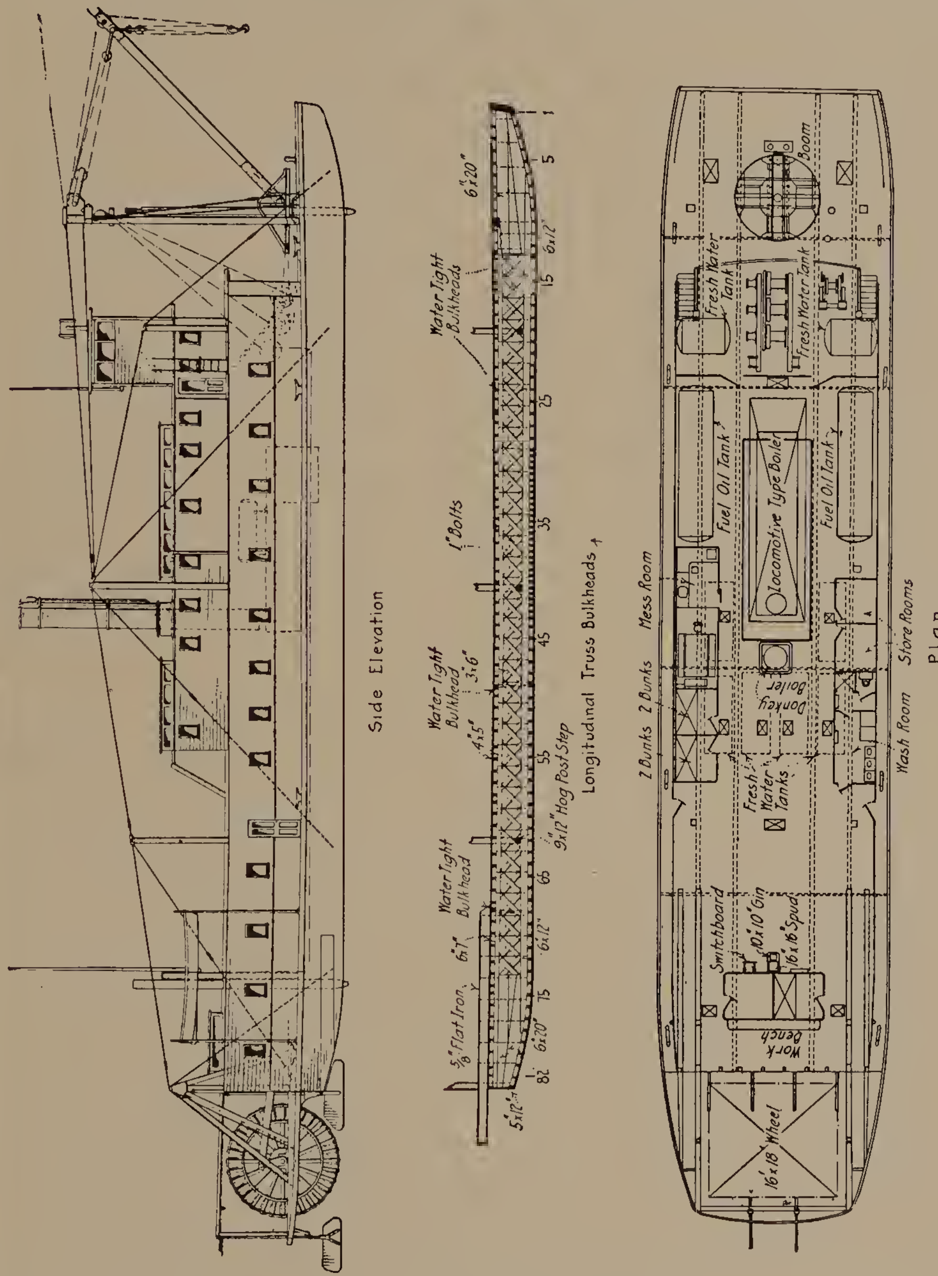
Passenger packets are generally of pushboat type and often the two functions are combined. The main difference in the packet boat proper and the pushboat is in the bow, the packet boat bow being of ordinary ship-shape form with the well known Mississippi



For work on the Mississippi — self-propelled, self-unloading barge with cargo "box."

gangway arranged to hang from a derrick over the front. Excursion packets are still maintained, and largely modeled on the lines of the famous old Western packets. They are side wheel propelled, the side wheels being abaft amidships. The capacity of such ships is enormous and the deck arrangements are ingenious. One of these vessels with a length overall of 300 ft., a beam molded of 45 ft. 6 in. and a draft of 5 ft., has four decks above the main strength deck, a passenger capacity of 5500, a crew of 70 and a speed of 20 m.p.h. At the time of her completion in 1925, this ship had the largest excursion passenger capacity of any ship in the American registry.

Excluding, for the moment, dredges which are considered separately the only other type of importance on the Western Rivers



Arrangement of a Snag Boat showing longitudinal truss girder construction and derrick hoisting arrangement.

is the self-propelling barge which is actually a hybrid between the ordinary barge and the pushboat. Inland Waterways Corporation has done much to foster this type of ship, and a particularly efficient class of self-propelling inland waterways freighter designed to operate on the Mississippi between St. Louis and New Orleans or on the Tombigbee, Alabama, and Black Warrior Rivers is illustrated opposite.[1] Length overall is 280 ft., with a beam molded of 49 ft., a depth molded of 10 ft., and a maximum draft of 7 ft. The hull shows the usual barge section with bows shaped slightly for easy entrance, and with two tunnels aft.

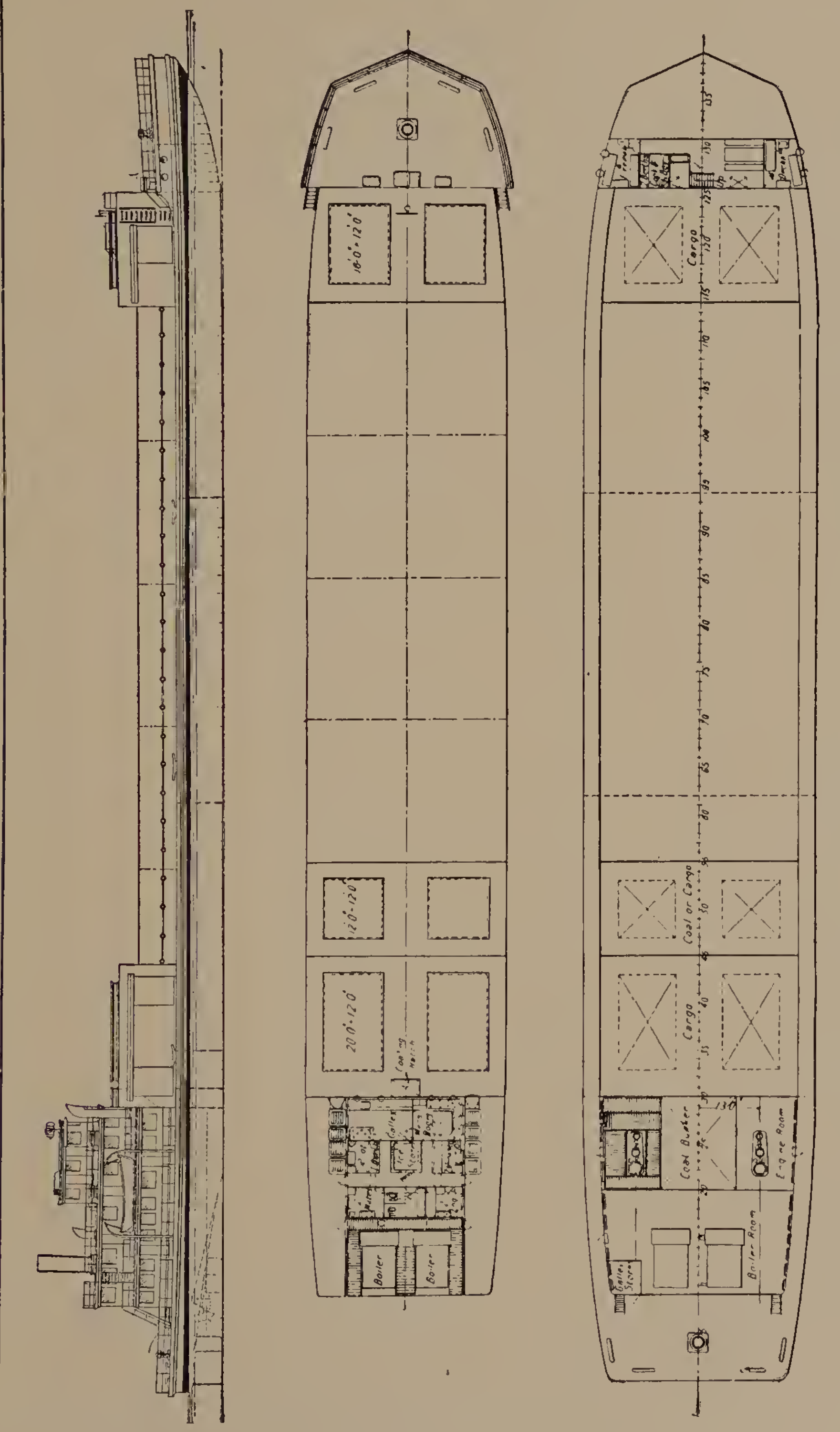
Cargo is carried on the main deck. An open cargo box, somewhat forward of amidships, provides for 1600 tons of coal. At each end of the coal box are enclosures for package freight, the forward enclosure being 24 ft. long, provided with two hatches 12 ft. by 16 ft. in the top and a sliding door in each side. The after enclosure is 50 ft. long with four hatches, two 12 ft. by 12 ft. and two 12 ft. by 20 ft., and has two doors to each side.

Crew's quarters are forward below deck, with accommodation for four deck hands, four firemen, cook and messman. The engine enclosure and principal quarters are in the after houses. The pilot house, with quarters for the captain, is on the top of the upper house.

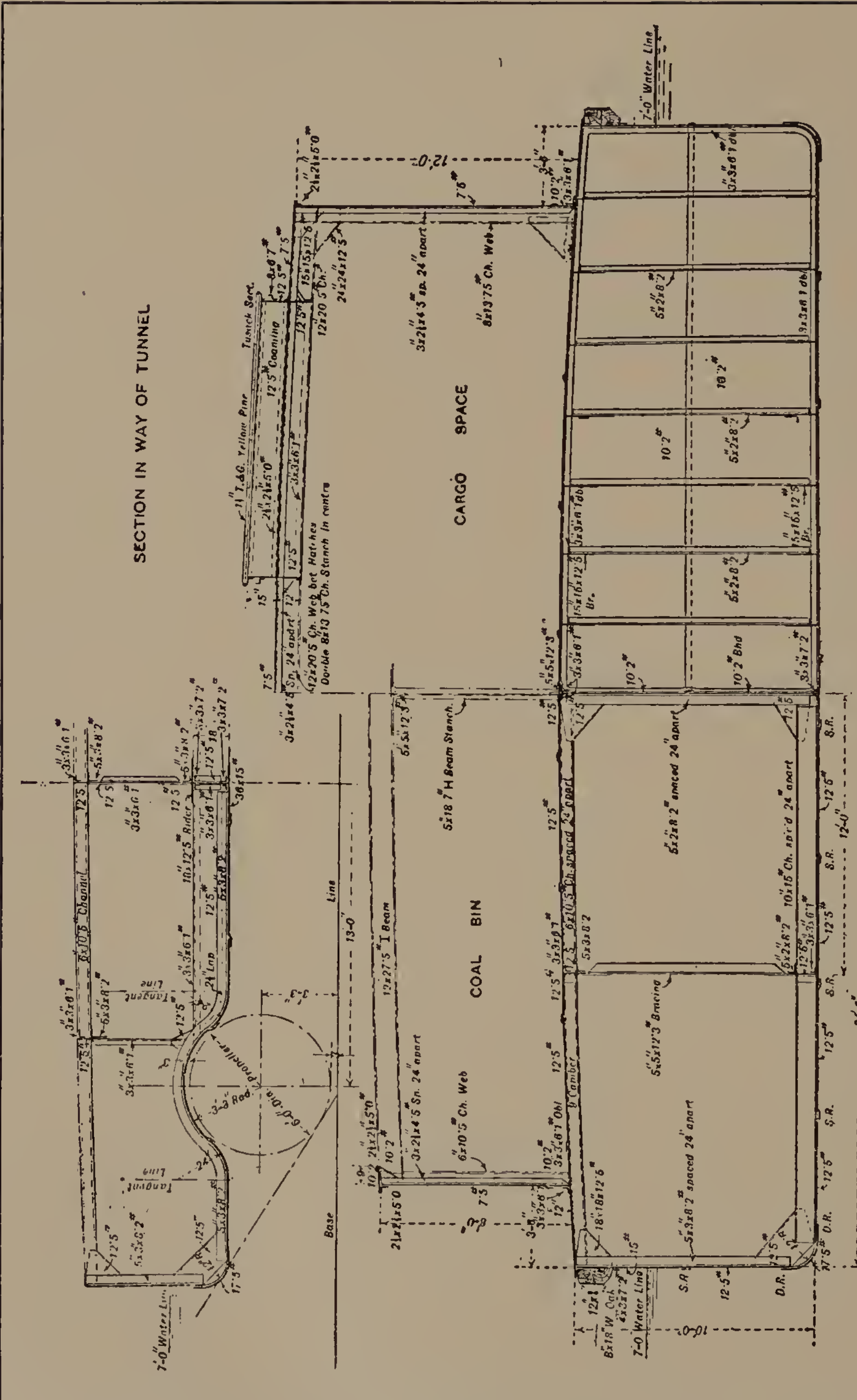
The two propelling engines have cylinders, of diameter $10\frac{3}{4}$ in., 17 in., 27 in., and 18 in. stroke, designed to operate at a working pressure of 225 lb. per sq. in., and to develop 400 i.hp. at 200 r.p.m. There is one surface condenser of 1100 sq. ft. cooling surface, with independent air and centrifugal circulating pumps. The boilers are of marine water-tube type, each with approximately 1400 sq. ft. heating surface, and 39 sq. ft. grate surfaces, arranged for bituminous coal, hand-fired, natural draught.

A $7\frac{1}{2}$ kw. generating set, is direct connected to a vertical steam engine, to operate at 80 lb. steam pressure per sq. in. The deck machinery includes a steam capstan at each end of the vessel, steam steering gear, chocks, cleats, etc.

[1] See "The Development of American River Traffic," *Shipbuilding and Shipping Record,* May 1, 1919.



Special self-propelling "box" barge used by Inland Waterways Corpn. for heavy duty on their Black Warrior service.



Constructional midship section of a self-propelling Western river freight barge of modern type.

In the tunnels are four balanced rudders, two on each side, one forward and one aft of each propeller. This arrangement is calculated to give the best results when going either ahead or astern. The propellers turn right and left, and the maximum speed is 8 miles per hour loaded.

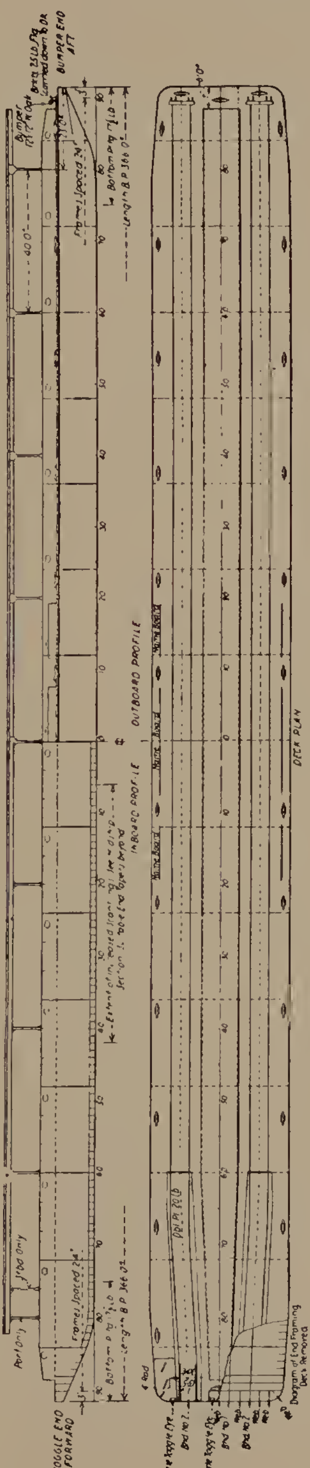
Snag boats — a very necessary adjunct to Western River navigation as well as that of Puget Sound — are virtually Western River pushboats with full scow bows and a large wooden pole derrick arranged to operate at the fore end having a 180 deg. operating swing. This derrick is arranged to operate in conjunction with a powerful winch.

Transportation of Freight Cars

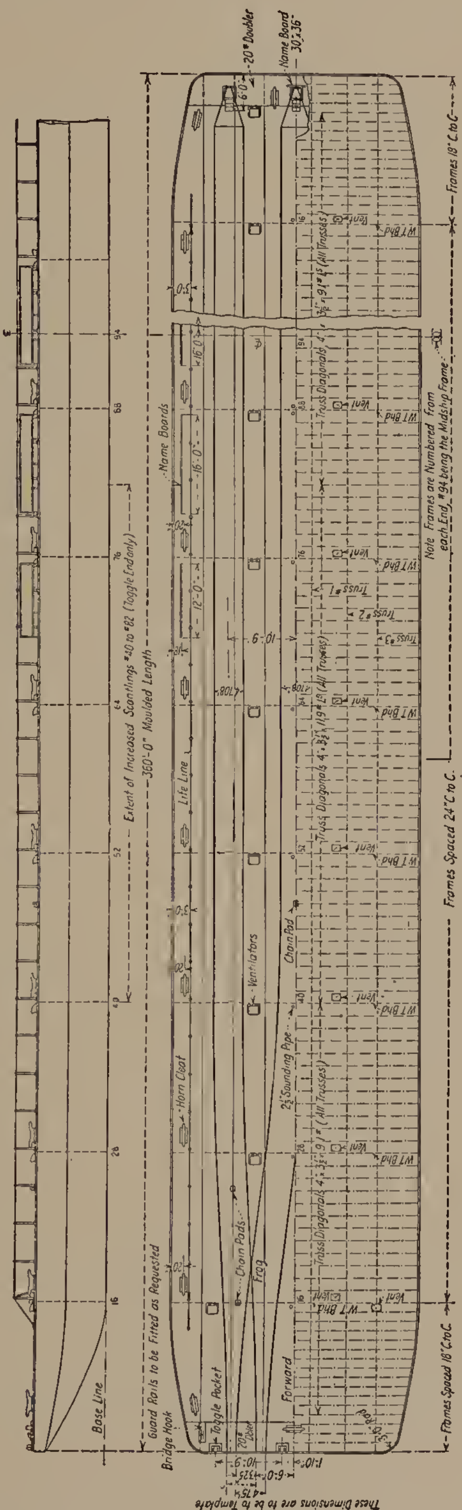
Is Carried Out on the Decks of Steel Carfloats

CARFLOATS are long, narrow, shallow structures with scow ends, employed in transporting railroad freight cars from terminal to terminal across a harbor or other stretch of water or from terminal to pier. They are internally stiffened by longitudinal truss girders and transverse bulkheads, in order to enable them to stand up to rolling loads occasioned when cars are moved on board, when the float is fast at one end to the float bridge and is thus virtually a cantilever beam. The internal stiffening also takes care of the ordinary stresses obtaining in the structure under tow. Carfloats are in many ways akin to ferryboats, and this relationship already has been commented on. They are among the most numerous and important of railroad owned floating equipment and are absolutely invaluable in ports such as New York, where in general two types are used — the 2-track and the 3-track. The 2-track type has a steel, roofed-in platform running the whole length of the structure and is used for conveying loaded freight wagons from a terminal to an unloading pier. The steel covered platform is used as a walkway for men with hand trucks who are engaged in unloading cars. The 3-track type is merely a transfer float and loads freight cars at one terminal to transport them to another terminal some distance away.

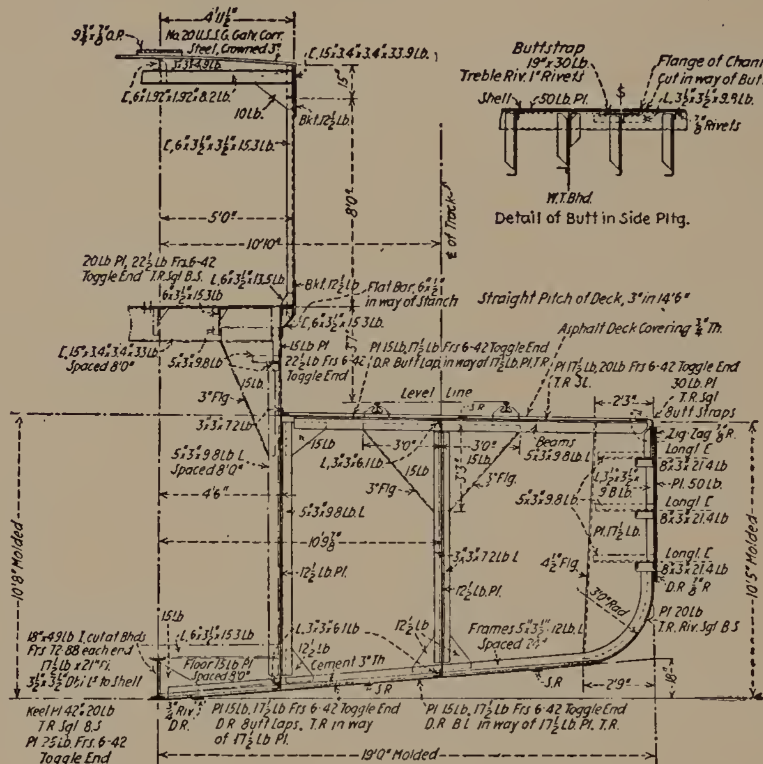
Modifications of the transfer float are used between Norfolk, and Cape Charles, Va., and between Vancouver and Nanaimo, B. C. The latter vessels, however, have their forward ends built up in ship shape form like a species of forecastle. The former is a duplicate of the transfer float, except that it is surmounted, or rather straddled, by a navigating bridge containing a power



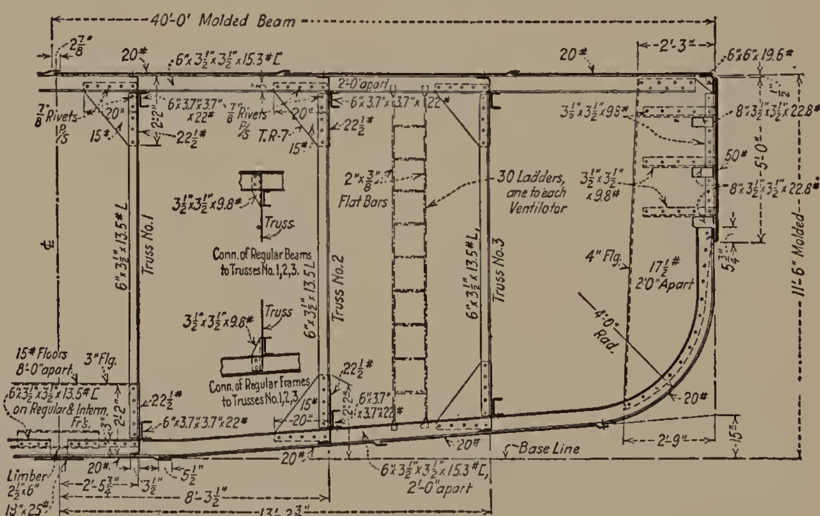
Outline arrangement of large 2-track carfloat with center platform, used for pier work.



Outline arrangement of large 3-track carfloat with clear decks, used for transfer work.



Constructional midship section of 2-track carfloat showing platform.



Constructional midship section of 3-track carfloat showing clear deck.

steering gear. Both these two carfloat groups are intended for open water work. The 2- and 3-track type with which we are more especially concerned in this chapter are intended for harbor work.

Wood was formerly largely employed as a material of construction and it proved very successful. Many wooden carfloats are in operation at the present day and are likely to remain so for many years. Steel is the material now universally used, and a steel hull 366 ft. 3 in. long by 35 ft. beam by 10 ft. 5 in. depth has 15 transverse watertight bulkheads and four longitudinal bulkheads which take the place of trusses ordinarily fitted. The boat is a two track type and the two inner girders form the sides of the platform extending up through the deck. The deck,[1] girders and bottom shell plating thus form a box girder of considerable strength. The two outer girders are spaced 10 ft. $9\frac{7}{8}$ in. from the centerline, bracketed to the deck and bottom, and are continuous from end to end of the structure, the transverse bulkheads being intercostal to them. Heavy web frames are fitted at regular intervals and specially heavy plating riveted to longitudinal channel bars takes the place of the wooden fenders formerly employed.

A three-track float 360 ft. in length by 40 ft. beam molded by 11 ft. 6 in. depth molded has 14 transverse bulkheads and six longitudinal trusses spaced 2 ft. $5\frac{3}{4}$ in., 8 ft. $3\frac{1}{2}$ in. and 13 ft. $2\frac{3}{4}$ in. from the centerline respectively.

[1] See "Large Car Floats for New York Harbor Service," *Marine Engineering and Shipping Age*, October, 1926, from which the illustrations are reproduced with acknowledgments.

Great Lakes and Canal Freighters

Models of Efficiency in Handling All Bulk Cargoes

THE design of freighters on the Great Lakes is influenced by special conditions not encountered on any other waterways. Foremost among these is the fact that navigation is only open for a certain period — about 8 months — in the year. This has a tremendous effect because it means that each ship must be built to handle the maximum amount of cargo which her dimensions will permit, and her cargo spaces must be so arranged that the minimum amount of time is occupied in putting the cargo on board and taking it out again at its destination. While these are desiderata for all ships, they are especially so for Great Lakes Freighters. The second factor influencing design is that most of the cargo handled is of a bulk nature — grain, coal and ore. These commodities being of a "fluid" nature, fortunately, can be handled quickly. The ordinary shipping world knows that. But even so, the term "quickly" can scarcely be said to have satisfied Lake ship owners, because they have set up on their shores plants which handle cargo literally with lightning rapidity, the like of which can be seen in no other ports in the world other than the Lake ports. Baltimore loads coal speedily; Cruz Grande in Chile has loaded iron ore at 414 tons per min. The Duluth and Iron Range Railroad ore dock at Two Harbors, Minn., has loaded at the rate of 758 tons per min. New York and Sparrows Point unload ore with commendable speed. European ports, generally speaking, cannot even be said to come into the picture at all where the handling of bulk cargoes is concerned — for lack of good handling facilities and because the demand for speed in handling does not exist, or at any rate does not appear to exist. But on the Lakes

speed is the Alpha and Omega of design and where the ocean shipper talks in terms of hours, the Lake shipper thinks in minutes, and some owners have gone so far as to ignore the facilities for cargo handling on shore and to provide their ships with unloading facilities operated from the main power plant.

Another factor of extreme importance is the smallest lock in the Welland Canal which is instrumental in sharply dividing the whole of the freight tonnage on the Lakes into groups — the large ships which may be anything up to 600 ft. in length and which cannot operate east of Buffalo, and the small ships, limited to around 250 ft. in length, which pass the Welland canal, navigate the St. Lawrence to Montreal and Quebec, and, theoretically, trade on the coasts as far south as Jamaica in the winter months when the Lakes are closed. Actually it is more economical to lay them up. There is also a third group — sisters to the "canallers," as the Welland ships are called — the N. Y. State Barge Canal group comprising freighters not only capable of navigating the Welland Canal, and restricted as to dimensions by locks, but also restricted as to the 15 ft. headroom by the lowest bridge on the Barge Canal.

Bulk freighters are the most numerous class of ships on the Lakes and it is with them that we are principally concerned in this chapter. Package freighters are actually moderate sized bulk freighters fitted with cargo booms and winches and in some cases cargo "houses" on their main decks. Otherwise they retain all the Great Lakes ship characteristics.

"Transportation on the Great Lakes," a very excellent 1926 War Department publication, which should certainly be consulted by anyone interested in Great Lakes freighters, gives some illuminating figures on the manner in which bulk cargoes are handled and the rapidity with which they are loaded and discharged. Here is a table which summarizes some of the records set up in this work.

These figures show that unloading is almost as rapid a process, in many cases, as loading and quite bear out the thought that no time is wasted in Lake transportation.

BULK CARGO HANDLING RECORD

Quantity	*Cargo*	*Time*	*Rate*	*Location*	*Process*
14245 tons	Coal	4 hr. 30 min.	3165 tons per hr.	Conneaut	Loading
9606 tons	Coal	6 hr. 50 min.	944 tons per hr.	Buffalo	Loading
14614 tons	Coal	11 hr. 15 min.	1299 tons per hr.		Loading
10073 tons	Coal	7 hr. 55 min.	1272 tons per hr.	Duluth	Unloading
14269 tons	Coal	12 hr. 25 min.	1149 tons per hr.	Duluth	Unloading
355,000 bu.	Grain	5 hr. 0 min.	71,000 bu. per hr.	Pt. Arthur	Loading
130,000 bu.	Grain	1 hr. 0 min.	2166 bu. per min.	Ft. William	Loading
451,382 bu.	Grain	15 hr. 0 min.	30,092 bu. per hr.	Buffalo	Unloading

Large Bulk Freighters

The principal limiting factors in the size of the large bulk freighters which do not operate east of Buffalo are the dimensions of the locks in the Canadian and American canals at Sault Ste. Marie. These locks are about 900 ft. in length and the Canadian ship canal is 7472 ft. long. Actually, the largest freighter does not approach anywhere near the length of the lock, the economical length being in the neighborhood of 600 ft., a ship of this size having a cargo capacity of about 13,000 tons, a beam molded of 60 ft. and a depth of 30 ft., — a length-beam ratio of 10 to 1 and a length-depth ratio of 20 to 1. These proportions for the largest Great Lakes freighters are somewhat greater than in ocean going shipping, but are justified because of the lower waves met with on the Lakes. Maximum depth molded is largely affected by the average depth of water available in Lake Erie — the shallowest lake — and does not exceed 32 ft. Canals, canal locks, and shallow water, coupled with the necessity for a large carrying capacity, have all tended to produce long hulls with parallel middle body extending for practically 75 per cent of the length. This is the tendency in all craft designed to carry bulk cargoes, in which one

of the dimensions is restricted. It is particularly noticeable in the case of the large river ships or barges which navigate the European inland waterways where the draft is limited to a few feet. A given cargo carrying capacity has to be realized therefore by

Courtesy Canadian Pacific S.S. Co.

A typical large bulk freighter in Great Lakes trade.

abnormal increase of length. The other solution to the problem is to split up the cargo carrying capacity into a small number of barge units and this is done on the Western Rivers. It is an excellent plan when waterways are restricted and where weather conditions are good and no heavy seas are encountered. Conditions on the Great Lakes do not permit of such an arrangement. The largest quantity of cargo possible must be delivered in the shortest possible time and in one bottom, because of the limited time in which navigation is possible on the Lakes and of the continuous demand and supply for the bulk commodities — grain, ore, and coal — carried.

The result is that the Great Lakes bulk freighter is literally a huge, self-propelling barge with machinery aft, navigating bridge right up forward, and a long clear parallel almost box-shaped cargo hold between. The machinery portion aft and the forward end are only ship-shaped parts of the hull. An actual freighter

590 ft. in length b.p. has a parallel middle body of no less than 415 ft. with 75 ft. of very full entrance and 100 ft. of run. Such a ship has a block coefficient of about 0.80. Following is a comparison between a Great Lakes ore carrier and an ocean-going ore freighter of approximately the same dimensions, which shows how the dimensional proportions of the two types contrast.

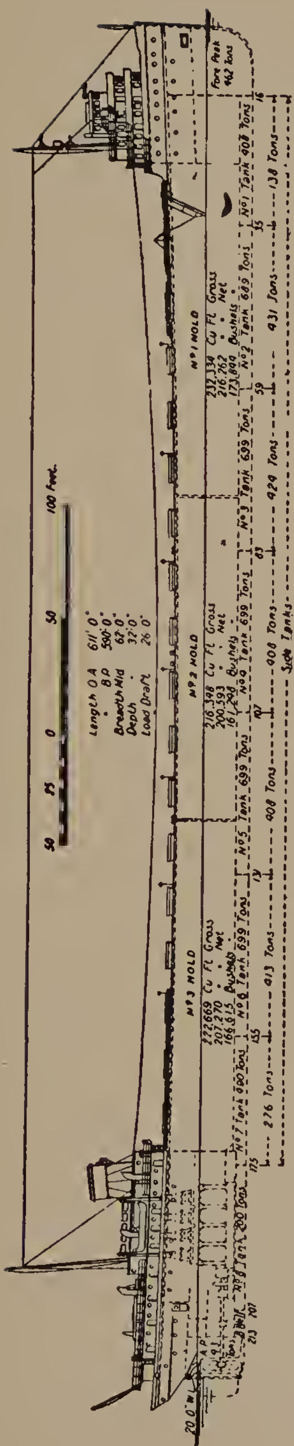
Lake and Ocean Bulk Freighters Contrasted

	Lake Type	*Ocean Type*
Length b.p.	592 ft.	550 ft.
Beam molded	62 ft.	72 ft.
Depth molded	32 ft.	32 ft. 4 in.
Dwt. capacity	13,000 tons	20,000 tons
Length/beam	9.5/1	7.6/1
Length/depth	18.5/1	17.2/1
No. of decks	1	1

The Lake freighter has a bigger length/beam ratio than the ocean freighter, while the length/depth ratios are practically the same in either case which goes to prove that capacity is secured by abnormal increase of length rather than by increase of depth. Besides this, increase of length with big length of parallel middle body makes for ease and cheapness of construction — an important factor in the biggest ships.

Hatches

Speed of cargo handling being the main feature of design — as we have seen already — clear holds and wide hatches are an absolute necessity. The wider and more numerous the hatch spaces, the more quickly can grabs remove the contents of the holds. The ideal freighter would have a clear hold extending from fore peak to forward machinery space bulkhead and open at the main deck level from end to end. Considerations of strength and seaworthiness forbid this and actually the open space is covered in by a large number of hatchways of width about 80 per cent of the beam molded of the hull and spaced center to center to suit the spacing of the coal and ore spouts, or the grain elevator discharging less in the particular trade in which the ship is engaged. This spacing generally is 24 ft. and the hatch spacing is



Inboard Profile of large Lake bulk freighter showing disposition and capacities of holds, peak tanks, and water ballast spaces.

12 ft. in the majority of ships. As an example of the numbers of hatches carried, it may be mentioned that a freighter 504 ft. in length b.p. has 29 hatches, while a larger vessel — 588 ft. b.p. has 35 hatches. The spacing and arrangement of hatch openings has an important effect upon the structure of the hull, as will be seen later. The hatch covers — contrary to conservative and inefficient ocean-going practice — are of steel plate section arranged to fold outwards from the centerline in two "heaps" between the hatch coaming and the ship's side. The outside plate slides out first and is followed by the next inside, and so on up to the centerplate. Covers are generally left off on voyages, except in bad weather, and natural ventilation alone is employed for the cargo. Coamings seldom are more than 2 feet in height and are built straight up from the deck at a distance of 2 ft. to 3 ft. on the outboard side of the actual hatch opening.

Hull Structure

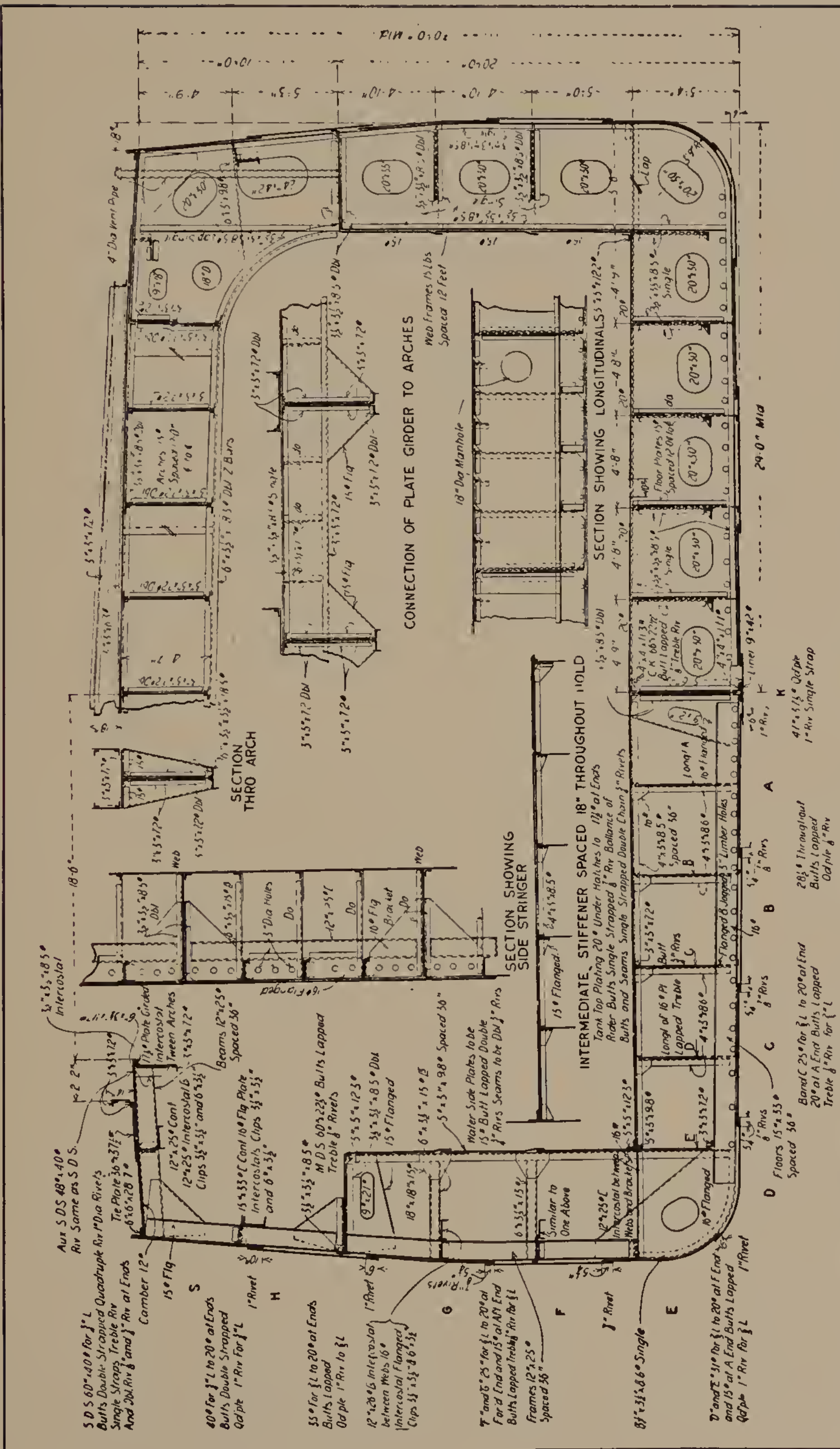
Coamings are expected to contribute nothing to the longitudinal strength of the Lake Freighters. The reason is the demand for clear holds, which, in conjunction with a large ballast tank capacity to make the ship manageable when light, has resulted in a particularly strong type of hull structure. This is in contrast with ocean-going bulk freighters and with the bulk cargo barges on the inland European

waterways. The latter rely entirely upon their hatch coamings for longitudinal strength, while the former usually have their coamings designed to contribute something to longitudinal strength by having all coamings continuous fore and aft.

In the Lake freighter, adequate strength is provided, in conjunction with clear parallel holds, by deep floors and strong deep angle frames spaced — in the larger type of vessel — 36 in. and deep web frames spaced 12 ft. These webs extend "round" the ship; i.e., up the sides and under the deck, being carried under the deck in the form of an arch and worked in between each hatch opening. The ordinary frames have light fore and aft frame structures worked in front, of the same width as the plate webs, and extending two-thirds of the distance up the ship's side, forming actually in conjunction with the plate webs, water ballast tanks, spaces for auxiliary steam and ballast piping, and communication between the pilot house and engine room. Plating worked in front of the webs forms the faces of the side ballast tanks. The flat top to the side tanks is the topmost of a series of longitudinal side stringers arranged in the side tanks and strongly bracketed to the transverse plate webs.

The double bottom may be as much as 6 ft. in height; the skeleton floors attached to and spaced 36 in. with the skeleton webs have deep channel margin bars at the bottom, and these are absolutely straight for about three-quarters of the vessel's length; i.e., the whole of the parallel midship portion. The turn of the bilge is formed by an ordinary angle bar. There are no bilges and the tank top is run straight out to the ship's side and connected to the shell by boundary angles. The tank top has flush plating — this is necessary because of the action of the grabs — and butt straps, intercostal between floors, on the underside of the tank top plating secure this.

Forward, the ship's lines are bluff and a specially recessed hawse pipe prevents the anchor from projecting outside the ship's hull and thus obviates any possible damage when proceeding through canal locks. Rudders are of semi-balanced type — this is common practice on the lakes — and the stern frame is of "open" type; i.e.,



Constructional midship section of typical large Lake bulk freighter showing disposition of girders, distribution of tanks, shape of floors, etc.

having no rudder post with pintles attached. A bearing in the stern frame bottom takes care of part of the rudder weight.

Details mentioned above may be checked and expanded on reference to the foregoing midship section, reproduced with acknowledgments from "Cyclopedia of Shipping." Following is a table giving main scantling particulars of a 500 ft. ore freighter, which may be taken as typical.

Lake Freighter Scantling Table

Item	*Scantling*	*Details*
Frames:		
Skeleton webs	36 in. spacing 14 ft. 6 in. high	Shell bars 12 in. channel Inner bar 5 in. × 3 in. angle 2 tiers of stringers in tank
Plate webs	12 ft. spacing 14 ft. 6 in. high	5 ft. 6 in. wide, 15 lb. plating $3\frac{1}{2}$ in. × $3\frac{1}{2}$ in. face bar, $3\frac{1}{2}$ in. × $3\frac{1}{2}$ in. shell bar
Deck webs	12 ft. spacing 4 ft. 7 in. deep	Fitted between hatch openings, "Z" bar face angles $3\frac{1}{2} \times 3\frac{1}{2}$ in. deck bar
Deck beams	36 in. spacing	Fitted in way of hatch opening, 12 in. channel
Double Bottom:		
Skeleton floors	36 in. spacing	Shell bars 15 in. channel. Tank top bars 3 in. × 3 in. angle. 4 longitudinal girders
Web floors	12 in. spacing	5 ft. 6 in. deep, 15 lb. plating. $3\frac{1}{2} \times 3\frac{1}{2}$ in. boundary bars.
Plating:		
Keel	47 in. wide	$37\frac{1}{2}$ lb. plating
Tank top	Flush	20 lb. under hatches, $17\frac{1}{2}$ lb. at ends
Tank sides	Inner	15 lb.

Dimensions:

Beam molded	58 ft. 0 in.
Bottom tank height	5 ft. 6 in.
Side tank height	14 ft. 6 in.
Side tank width	5 ft. 6 in.
Web (deck) height	4 ft. 7 in.
Depth molded	30 ft. 0 in.
Spacing of longitudinal intercostals to floors	4 ft. 9 in., 4 ft. 8 in., 4 ft. 8 in., 4 ft. 9 in.
Spacing of longl. intercostal side stringers from tank top	5 ft. 0 in., 4 ft. 10 in., 4 ft. 10 in.

Equipment

Great Lakes bulk freighters, although limited naturally to comparatively short runs, are extraordinarily well equipped both as regards accommodation and as regards navigating gear. The principal cabins are situated in the "texas" forward on the forecastle, and in the forecastle itself, and include berthing for mates, wheelmen, watchmen, boatswain. The captain, in the larger ships,

"Texas" and forward end of a typical Lake freighter.

occupies a large portion of the "texas" proper with his bedroom, bathroom and office. The owner also has luxurious quarters in this locality. Mates and crew are provided with well fitted sitting rooms and bathrooms. In fact, the Lake standard of accommodation is considerably superior to that usually found in sea-going bulk cargo ships. The "texas" upon which the pilot house is built occupies an important place in the history of American domestic ship type development, and the derivation of the term is interesting. The present term "stateroom," so universally used and often abused by shipping companies, owes its inception to the

practice of designating sleeping rooms on the old Western River passenger packets by names of states — such as Pennsylvania, Vermont, Indiana, etc., instead of by numbers or letters, as is the general custom at present. Quarters for the officers and crew invariably were placed on the top of the passenger quarters, and following the state nomenclature religiously, builders designated their largest rooms, i.e., the crew's quarters, by the name of the largest state in the Union — Texas. Theoretically, therefore, the "texas," bereft of its T accommodates the whole of the crew. Actually it does nothing of the kind on the Lakes because all engineers are accommodated in a house round the engine and boiler casings aft, and only the élite of the crew have access to the "texas" proper, the majority, as we have seen, being relegated to the roomy forecastle below. Old customs die hard, however, even in this progressive country, and the Lake freighter retains her texas, while many of the Lake cruising ships still retain the nomenclature for their *suites de luxe*. It is a pretty custom which gains rather than looses charm with age. American ship constructors have given something to shipping internationally in the term "stateroom."

The forecastle deck forward of the texas in the largest freighters usually is clear of any windlass or anchor gear, its function being somewhat similar to that of the quarterdeck on warships acting as a promenading space.

As an example of the work carried out in fitting out the accommodation of large Lake freighters, the following details of a 500 ft. ship are worth noting. The forward part of the texas is occupied by an observation room, and this together with the captain's office and bedroom situated immediately behind are paneled with sawed oak veneer. The ceilings are rough finished and fitted with painted canvas panels. The rest of the cabins are ceiled with narrow "V" joint oak. The pilot house is stained and finished green with a painted pine ceiling. All floors are of pine in sections, except the galley, pantry and crew's mess rooms.

People acquainted with ocean-going shipping, will do well to note the above details. They are, however, indicative of the gen-

eral tendency of American ship owners to fit their ships with every comfort for officers and crew.

Deck equipment comprises a windlass, which is housed in a special room in the forecastle forward of the crew's quarters and which controls the two anchors stowed in recessed hawse pipes.

New style pilot house with Diesel-electric control.

Mooring machines are also fitted on the decks — one 600 ft. ship has five forward, four at the break of the forecastle and five aft, (four at the beak of the poop house and one quite aft). These actually are winches, automatic in action, and they require to be fitted for mooring purposes, instead of relying upon the stereotyped bollards, because of the extremely rapid increases and decreases of draft which take place during loading and discharging of bulk cargoes. The increases are big in all cases in loading such commodities as grain, coal, and ore. The decrease is greatest in

the case of grain, which is rapidly removed by means of suckers. The other commodities have to be removed by grabs. The mooring machines take in and pay out mooring cable automatically as required.

Navigational equipment has undergone considerable changes in the direction of efficiency recently — especially in the Canal freighters, by the introduction of engine revolution indicators, gyro compasses and automatic steering, electric engine room telegraphs, radio compasses and direction finders, and even pilot house control in the case of certain recent electrically driven ships. These refinements belong actually to the Diesel engine, and their introduction is contemporary with that of the Diesel to Lake ship propulsion. Meanwhile the position of the pilot house far forward on the forecastle demands the presence of the old time steering pole — a familiar and domestic characteristic found on all Great Lakes ships and on the majority of ferryboats.

Self-Unloading Freighters

Some of the larger Lake freighters are fitted with self-unloading apparatus which renders them independent of shore apparatus for discharging their cargoes. This has the advantage of increasing the flexibility of the ship by allowing it to call at ill-equipped ports without losing any time and is especially useful in the case of ships engaged in the crushed stone trade. Many stone crushing plants along the Great Lakes shores find their readiest market in near-by towns unequipped with unloading docks, and in delivering to these towns by ordinary freighters, it is found that the vessel often is tied up at the dock for a longer time than that occupied in actual transit. The self-unloader discharges her cargo right away.

Self-unloaders differ in construction from ordinary freighters principally in their hold bottoms. They have, in effect, a false bottom to the hoppers having doors hinging downwards into the passage between the hopper bottom and the ship's bottom. The cargo falls out by gravity from the hoppers on to endless belt

conveyer systems in the passages. These belt systems convey any given unit of cargo,[1] either sternwards and upwards, or bow-wards and upwards to a point at about half the molded depth of the ship. Here it falls via a chute on to a bucket conveyer, which carries it up above deck level. At this point it is transferred into a third (belt) conveyer arranged to move in a semicircle about the fore and aft centerline of the ship.

A modification of this arrangement — and in some ways an improvement — has two cantilever conveyers, arranged on either side of a central operating tower. In this arrangement the belt systems are divided into two, working respectively from bow and stern toward midships. The design is a projected one, and aims at cutting the time spent in port by half, as well as reducing the friction of the whole system — a factor of considerable importance. The design is intended for use in conjunction with a special type of interior arrangement.

The conveyer and belt systems must be driven by some form of prime mover, arranged when possible near the main source of power for the ship's propulsion. Both the steam engine and the electric motor have found favor for this purpose; the latter has the advantage of flexibility, in that it need not be placed near the main source of power, neither does it require long lengths of lagged piping, as is the case with the steam engine. The following figures give an idea of the way in which unloading machinery is arranged on a typical self-unloading freighter.

The example is 430.3 ft. o.a. x 56 ft. x 30 ft. molded. Capacity, 8000 tons ore at 19 ft. draft, or 6000 tons coal at 16 ft. draft. Water ballast, 5200 tons; 21 hatches.

An endless belt system under two lines of hopper doors, discharges to a pan conveyer, which in turn discharges into cantilever belt conveyer. Conveyers are driven by two 150 i.hp. steam reciprocating engines situated in the forecastle (the main propelling machinery is aft). One engine drives two of the horizontal conveyers, and the other the pan conveyer, the belt conveyer in the cantilever, and the winch which raises and lowers

[1] See also the author's "Bulk Cargoes."

the boom. The two engines are interchangeable, and are controlled from the deck.

Unloading rates vary with the unit size of cargo — small units being easier to handle than large ones — with the type of machinery employed, and with the intelligence of the men handling the plant. An ore carrier, for example, fitted with a cantilever belt discharge, having a deadweight capacity of 12,000 tons, has an unloading rate of about 1800 tons per hour.

A stone carrying vessel, 310 ft. in length and 3300 tons capacity has an unloading capacity of 600 tons per hour; a similar ship 370 ft. in length with 5700 tons capacity discharges at 750 tons per hour, while a third example 436 ft. long and 8300 tons capacity unloads 900 tons per hour. In each ship, cargo is carried in a double row of hoppers having bottom gates, beneath each of which is a 36 in. pan conveyer, 188 ft. long, operating horizontally. The pan conveyers discharge to a single belt conveyer 42 in. wide and 100 ft. long, rising on an incline to the stern to a point above the deck. A further belt conveyer — 42 in. belt by 80 ft. centers, is carried on a steel truss revolving boom, which can discharge on either side of the ship. A 90 hp. motor drives the two pan conveyers and inclined belt conveyer. The boom conveyer is operated by a 35 hp. motor.

Cement in Bulk

In a paper on self-unloading vessels, read before the Society of Naval Architects and Marine Engineers,[1] an unique self-unloader designed to carry cement in bulk was described. The broad principles of operation were the same as in other ships, except that, owing to the nature of the cargo, a screw conveyer had to be used. Cement in bulk, especially when aërated, is practically the same as a liquid cargo, but toward the end of the voyage it is apt to become "caky." On re-aëration, however,

[1] "Self-unloading Bulk Cargo Vessels of the Great Lakes," by Henry Penton and Herbert C. Sadler, D. Sc., *Trans. Am. Soc. Naval Arch. and Mar. Eng.*, New York, 1925.

it flows freely. Consequently, the ship in question was fitted with an air compressor and apparatus for forcing air through the cargo. The decks were completely plated, with the exception of small circular openings about 18 in. diameter, through which the cement could be loaded. Shifting boards were arranged in the holds, because, from the point of view of stability, cement, like grain, is practically a liquid cargo. The vessel had a deadweight carrying capacity of 5700 tons. Her loading rate was about 4500 barrels, or 850 tons per hour, while her discharging rate was 2400 barrels, or 460 tons per hour, the whole of the unloading plant being electrically operated.

In most self-unloaders, the usual midship section outline is maintained; but within this, there is a further structure, in outline like a very widely spread W, with the two bottom corners flattened off. This is necessary in order that the cargo may flow by gravity to the flattened parts in which hopper doors are arranged, communicating to the fore and aft passages along which belt conveyers run. The space between the side arms of the W and the ship's side is very conveniently employed for the carriage of water ballast, while the peak made by the center of the W serves as a useful inspection chamber to the conveyer machinery. Besides the peaks made by the 'thwartship W, there are also fore and aft peaks arranged to assist the flow of the cargo by gravity in a fore and aft direction. Although, in the main, this "W hopper" system is the only reasonable way of dealing with cargoes for self-unloading, and while the arrangement is of considerable use for the mechanical side of the operation, it is not without disadvantages. There is the loss in deadweight capacity over a similar ship not fitted with self-unloading plant. The presence of the W raises the cargo, and consequently raises the center of gravity of the loaded ship with a tendency to reduce the metacentric height, although where the case of an ore cargo is considered, this may be an advantage. Increasing the beam and depth of hold does to a certain extent compensate the loss of deadweight space, but beyond a certain point (Messrs. Penton and Sadler in their paper already quoted consider about 12,000

tons), this does not in proportion produce increase in capacity, because of the area cut off by the hopper.

Suggestions have been made to overcome this disadvantage, and an arrangement, designed by Messrs. Penton and Sadler, and described in their paper, allows for a flat hopper bottom with leaves of each side constrained to open outwards and upwards. The cargo first flows to the conveyers in the usual manner, and then, when the flow is about to cease, the doors, hydraulically operated for preference, open upwards, pushing the remainder of the cargo into the conveyers. This arrangement allows of a closer spacing of conveyers, while increase in beam and depth produces increase in capacity.

A self-unloader of more than usual interest from the point of view of arrangement comes from a Canadian source. It is a single deck collier of canal type of 2200 tons deadweight capacity, operating also on the St. Lawrence River, and there are two large holds, each served by a wide hatchway, which extends the full length of the cargo space, except for a distance amidships, where the conveyer machinery is situated. Water ballast is carried in two large double bottom tanks, in the fore peak and in topside ballast tanks. The unloading apparatus consists of a gantry running the whole length of the cargo space, and operating in two distinct portions — forward from midships and aft from midships. Along these two portions runs a grab which can be stopped over any particular part of the open hatchway and lowered. Then, having picked up its cargo, the grab is raised and returned along the gantry to midships, where it empties its contents *via* a feeder on to an endless belt conveyer, discharging ashore. The operator's cabin for the gantry system is arranged high up under the gantry, giving a clear view of all operations in progress, while the conveyor machinery is arranged in a space amidships under the main deck. The system is a very ingenious one, but the speed of unloading depends, of course, entirely upon the way in which the grabs are operated. The grabs have to make a journey out from midships empty, which absorbs power not lost in a belt conveyor system, although there is possibly more friction

in the latter. It is likewise open to debate whether the grabs on the ship plus the conveyor system could handle the cargo as quickly as a grab equipment working from the shore. The superstructure, too, is somewhat heavy and unwieldy with the ship rolling in a seaway. The whole equipment, however, makes the ship a self-contained unit capable of discharging at the most ill-equipped ports.

Quick Loading Ship

Marquette and Bessemer No. 1 is a canal type ship 255 ft. in length used for carrying coal in bulk from one Lake railroad terminal to another and has been designed specially to load her cargo with minimum handling for the railroad trucks. Her stern is constructed somewhat like that of a rail car ferry with railroad lines running the length of the hatches so that the coal cars can be run directly on to the deck and discharged into the holds. The superstructure and boiler uptakes aft are divided into two portions — one on either side of the railroad track.

Sideways Launching

The immense length of the larger Lake freighters and the comparatively restricted waterways alongside which many of the Lake shipyards are situated, practically rules out the stereotyped method of launching. The large Lakers therefore are built sideways on to the waterway and launched from this position. The problem of transferring a 10,000 — or 12,000 — ton bulk freighter from the shore to the water is by no means an easy one and it is one which is peculiar to the Lakes, being with few exceptions practised in practically no other part of the world.

Fixed ways are built down to the water in the usual way and sliding ways are arranged under the hull with cradles built above them. As many as six sets of ways are employed, the exact number depending upon the length of the ship. The ship slides into the water with a big splash, turning over on her side away from the land as she does so. Sometimes she goes so far

that the deck is at right angles to the water. The natural properties of stability, however, soon right her and she comes up on an even keel.

The following figures from an actual instance for sideways launching on the Great Lakes are abstracted from a paper on the subject read at the twenty-sixth general meeting of the Society of Naval Architects and Marine Engineers in New York by Mr. Edward Hopkins. The building berths, he states, are 80 to 100 ft. wide and the ships are built with no rake of keel. The inclination of ways is $1\frac{1}{4}$ in. to $1\frac{1}{2}$ in. per foot and the height of keel blocks is from 4 ft. to 5 ft., there being a drop of from 1 ft. to 8 ft. off the end of the ways. Following are the launch data for a comparatively small ship of 3500 tons deadweight having a length b.p. of 261 ft. by 43 ft. 6 in. beam.

Declivity of ways $1\frac{1}{2}$ in. per ft.; launching weight of ship 1170 tons; area of sliding ways 289.45 sq. ft.; time taken from the start of the launch to the vessel's leaving the ways 6.5 sec.

Canallers

Canal freighters operate over the whole of the lakes system and also from the Lakes via the Welland Canal and St. Lawrence River to Montreal and Quebec. The largest canal freighter is just smaller than the smallest lock in the Welland Canal system. Typical dimensions are shown in the table. Generally speaking, the canal freighter is a smaller edition of the Lake freighter with different hull proportions, and a slightly modified structural arrangement of hull. She spends a considerable proportion of her actual life getting in and out of locks and hence contact with gates and walls is frequent, with sometimes bad results to the hull structure. The canaller generally proceeds at full speed into a lock, trusting principally to the cushion of water formed to check the impetus of the ship. The locks on the Welland and Lachine canal systems are numerous and awkward to navigate, there being, for example, between Port Colborne and Montreal no less than 46 locks in some 387 miles.

Bilge and side shell plating are the parts of the canaller's hull most subject to damage, and this causes plating and framework

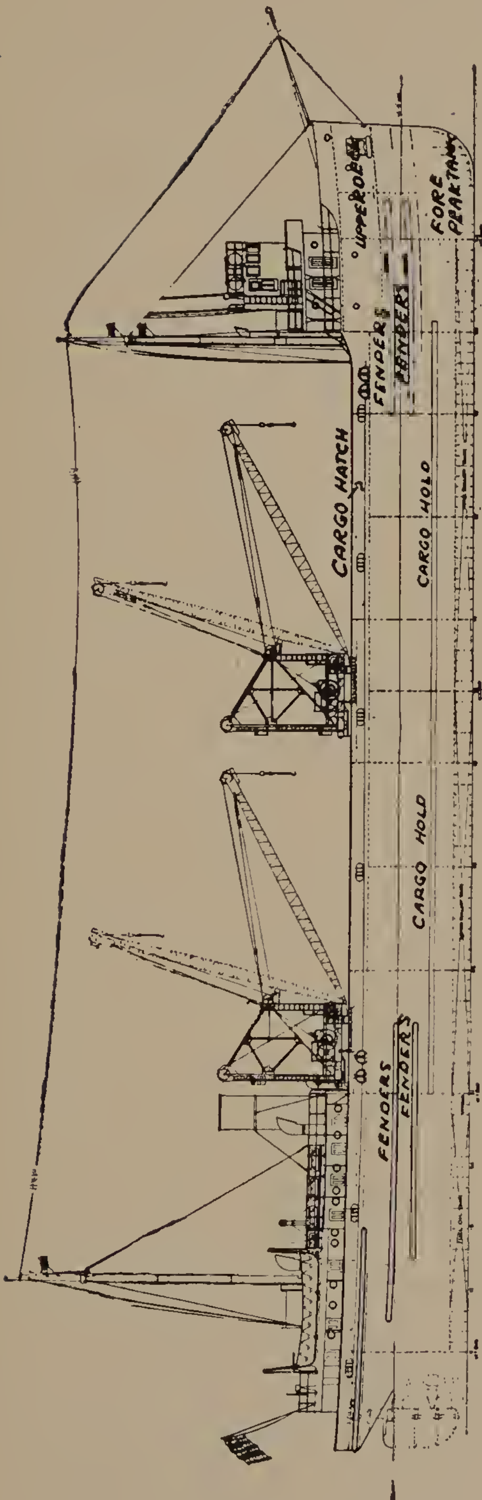
The bluff bow of the canaller is designed to withstand lock collision damage.

behind to be set in, with consequent damage to the riveting. Wooden or steel plate fenders are fitted, the former usually about 10 in. x 6 in. and the latter about 12 in. wide and 1 in. thick. The

wooden fender is fixed to the ship's side between angle bars, while the plate fender is riveted to the side. The very bluff bow is particularly liable to sustain damage, and two or three fenders are arranged here. In view of the fact that damage is experienced at the bilge in locks, special attention is devoted to the construction in this part. In general, designers aim at placing the line of rivet holes for the shell angle on the tank margin as far as possible from the points where the round of the bilge meets the ship's side and bottom respectively, as these are the positions at which leakage occurs. Inflow of water is particularly unfortunate in the case of grain cargoes, since it may cause damage to the whole contents of the hold.

Like the lake freighter, the canal freighter has her navigating bridge constructed at the extreme fore end and carries her machinery well aft. The same arrangement of semi-balanced rudder is also adopted. It is to be noted that neither the lake nor the canal freighter is at the period of writing subject to freeboard regulations. Draught, and therefore the depth molded is restricted only by the depth of locks through which the ships pass in the course of their operation.

There are fewer canal self-unloaders than Lake self-unloaders, chiefly on account of differences in service requirements for the two types. A self-unloading collier of canal type has been described already. U. S. Steel Products Co. has put in service a fleet of self-unloaders, designed for their special service, which are among the most up-to-date and well equipped vessels on the Lakes. The fleet consists of four sister ships of 1694 tons gross engaged in the transportation of steel plates and shapes from the U. S. Steel Corporation mills in the Chicago district to Montreal. Each ship has two cargo holds 80 ft. in length served by a hatch running the complete length of each hold and 20 ft. wide which permits of the ready entrance of big plates, structural shapes, and rails of long length. For lifting and swinging these lengths, there are two 5-ton electric revolving cranes of a type generally used on land as locomotive cranes. The ships thus can easily take on board their cargo direct at the steel mills and discharge with rapid-



U. S. Steel Products Co. has a fleet of four ships similar to this designed especially for transporting steel plates and shapes.

ity at the other end. General cargo is loaded for the return trip. Two ships — *Steelmotor* and *Steelvendor* — are propelled by single acting 4-cycle 6-cylinder trunk piston Diesel engines, one engine of 960 hp. per ship. One ship — *Steel Electrician* — has Diesel generators supplying current for a 750 hp. propelling motor, and the fourth — *Steel Chemist* — has a double acting 2-cycle 4-cylinder engine developing 950 i.hp. These ships have gyro compass equipment and automatic steering, while the electrically propelled ship has pilot house control. The Diesel-electric system of propulsion, which has a great deal to recommend it for ships engaged in lock and canal navigation, has been adopted with success in two canallers designed to operate between Duluth on the Great Lakes and New York via the New York State Barge canal. There are two such ships and while in dimensions and hull form they are canallers, the whole of the top structure has been modified to permit of their negotiating the bridges on

the canal system. One of these is illustrated earlier in the book in the section dealing with inland waters. The illustration well shows the low superstructure.

The trip from the head of the Lakes to tidewater in New York is scheduled for 10 days. These ships, named respectively *Twin Ports* and *Twin Cities*, can carry about 2000 tons of freight and were built for the Minnesota-Atlantic Transit Co., Duluth. The president of both these companies at the time of the ship's construction was A. Miller McDougall, son of the late Capt. McDougall, widely known as the inventor of the once familiar Great Lakes Whalebacks.

Whaleback steamers at one time carried the majority of Great Lakes cargo; they were flush fore and aft with very rounded gunwales; there were no hatch coamings in the ordinary sense of the term, the holds being merely closed by steel plates bolted to the deck. The most characteristic feature was the long spoon-shaped bow. Erections, if any, were narrow with walks extending round, and if there was more than one erection, a fore and aft gangway connected them. Some whaleback steamers had their bows modified to take a forecastle and pilot house and in this case a forward end of stereotyped form was fitted. A loaded whaleback, viewed end on, presented a most unusual experience. The type is disappearing from the Lakes.

COMPARISON OF GREAT LAKES FREIGHTER CHARACTERISTICS

	Lake	*Canal*	*Canal* (N. Y. Barge)
Length o.a.	600 ft. 0 in.	257 ft. 11 in.	258 ft. 0 in.
Length b.p.	588 ft. 0 in.	250 ft. 0 in.	250 ft. 6 in.
Beam molded	60 ft. 0 in.	42 ft. 9 in.	42 ft. 0 in.
Depth molded	32 ft. 0 in.	20 ft. 0 in.	19 ft. 0 in.
Draft	16 ft. 0 in.	14 ft. 0 in.	
Capacity	12,120 tons	2077 tons	2000 tons.
Tonnage	8,338 Gross	1694 Gross	1460 Gross
No. of holds	1 (3 screen bkds)	2	
Machinery	Steam	Diesel	Diesel-Electric
Power	2000 i.hp.	960 i.hp.	500 s.hp. (twin rudders)

Machinery

Until comparatively recently, all Lake Freighters were steam driven, reciprocating engines taking steam from cylindrical boilers.

Jet condensers were largely used in conjunction with this layout. This arrangement was easy and economical to operate, especially for ships engaged in the coal and ore trades where coal could be obtained comparatively cheaply. Some shippers, in fact, insisted as a condition for placing their business in carriers' hands that the vessels should bunker with their coal. Coal, too, was the natural readily obtainable fuel for the Lakes. Large 12,000 ton freighters require about 2000 i.hp. to give them a service speed of $11\frac{1}{2}$ to 12 knots. Henry Ford was the first man to show that the large Lake freighters could be, at one and the same time, Diesel propelled and economically operated, with ms. *Henry Ford II* and *Benson Ford* — ore carriers of 624,125 cu. ft. capacity — which each had a single screw driven by a 3000 b.hp. Sun-Doxford opposed piston Diesel. This layout was arranged in conjunction with all electric auxiliaries. These vessels have proved very successful on service and should form a precedent. Many types of American double acting 2-cycle engines and single acting 2- or 4-cycle engines are quite suitable for linking direct to propellers in these ships.

Diesels actually were introduced to the Lakes via the Canaller and in 1913–1914 several underpowered ships made their appearance. These mostly were British-built Canadian-owned ships and managed to collect such unsavory reputations for themselves that the Diesel engine became thoroughly discredited in Lake shipping circles, remaining so until far-seeing and progressive owners like Henry Ford and the U. S. Steel Products Co. proved conclusively that the evil reputation of the Diesel was nothing but a myth. The package freighter *Fordonian* is a case in point of one of the early Diesel ships. Constructed on the Clyde, she came out to the Lakes in 1913 equipped with a 4-cylinder 2-cycle engine, rated for 750 b.hp., at 120 r.p.m. Her performance in Welland Canal and other locks was regarded as unsatisfactory and she was sent to the Coast, and later left the American side of the Atlantic and went overseas, transferring later to American registry. In 1922 she was converted to Diesel-electric drive and since that has entirely altered her earlier bad reputation. In September, 1926, she was again sold to Canadian interests.

The Canaller is sometimes regarded as a more difficult proposition to Dieselize than the Laker, simply because of the locks and the rapid reversals of rotation of the propelling machinery. Extreme flexibility is a *sine qua non.* Diesel-electric drive in conjunction with pilot house control is very useful from the point of view, but has a greater first cost than steam or straight Diesel drive. The upkeep cost, too, may be greater than that of the straight Diesel, if the plant is handled carelessly or by inexperienced people. In September, 1926, Worthington Pump and Machinery Corp., fitted the first small double acting engine in the world to the steel-carrying freighter *Steel Chemist.* This engine, a double-acting 2-cycle 4-cylinder engine, developed 950 b.hp. at 15 r.p.m. and was conspicuous by its ease of maneuvering as well as by its economy of operation. An engine of this type should have a big future for Lake work — or at least for the Canal type of ship. Following is a table giving an outline of the power distribution on recent Canallers.

SHOWING POWER DISTRIBUTION ON MODERN CANALLERS

Total Power	850 s.hp.	750 hp.	900 i.hp.	950 b.hp.
Drive	Electric	Electric	Steam	Diesel (d.a.)
No. of Genrs.	2	3	—	—
Power of Genrs.	350 kw.	200 kw.	—	—
No. of Screws	1	1	1	1
Tonnage of Ship	2368 G.	1694 G.	1951 G.	1694 G.

Great Lakes Passenger Traffic

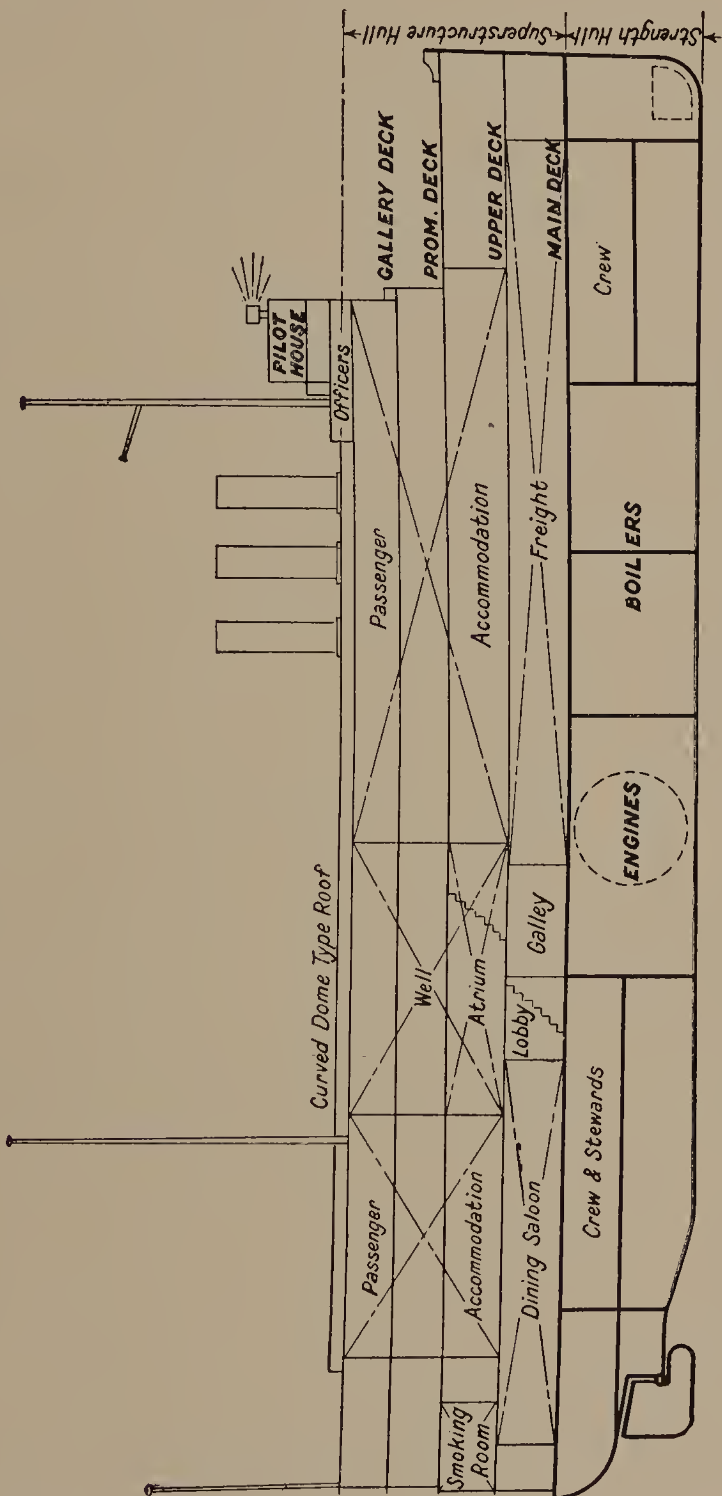
Is Handled by Giant Sidewheelers and Freighter-type Liners

WITH a few special exceptions, passenger services on the Great Lakes are maintained for pleasure cruising or excursion purposes. Many ships so engaged operate for a short period each year, some only being restricted by ice in common with other craft navigating the Lakes while others are kept in service merely during the tourist season. There are no special features in the pure excursion steamers worth calling special attention to — at any rate in vessels engaged in day runs — other than the features mentioned already in the chapter dealing with this particular traffic. Night runs, however, such as between Cleveland and Buffalo, Cleveland and Detroit, Detroit and Buffalo, have produced the largest, most complete, most luxurious side wheelers in the world, while the tourist traffic from Buffalo to points west and from Chicago to points east has given rise to a special type of passenger ship which cannot be found anywhere else in the world and which has been adapted from the Great Lakes freighter, the freighter in its turn having been evolved from a barge into the most efficient type of freight carrying ship — for bulk cargoes — that it is possible to construct. The giant sidewheeler has simply evolved itself and stands as a monument to the progressiveness and openmindedness of American shipbuilders and naval architects.

The Giant Sidewheeler

The giant sidewheelers of the Lakes are comparable, in overall dimensions, to large ocean-going passenger and mail liners. They are confined to Lake Erie for their operations. Their appointments are luxurious and outrival many ocean-going ships.

Ss. Seeandbee, over 480 ft. in length, a passenger carrier of type unique to the Lakes owned by Cleveland and Buffalo Transit Co.



Inboard profile of big Lake sidewheeler, vertically exaggerated, shows disposition of passenger decks, saloons, and freight spaces.

As might be imagined, they are comparatively few in number — in 1926 season there were nine — and of varying sizes ranging from the 550-ft. *Greater Buffalo* and *Greater Detroit* to the 350-ft. *Western States.* In order better to visualize the size of these fresh water monsters it is illuminating to place *Seeandbee* engaged in the Buffalo–Cleveland run beside *Matsonia* running regularly between San Francisco, Cal. and Honolulu. Both ships were built in 1913 and have been in continuous service since, *Seeandbee's* service being of course a seasonal one.

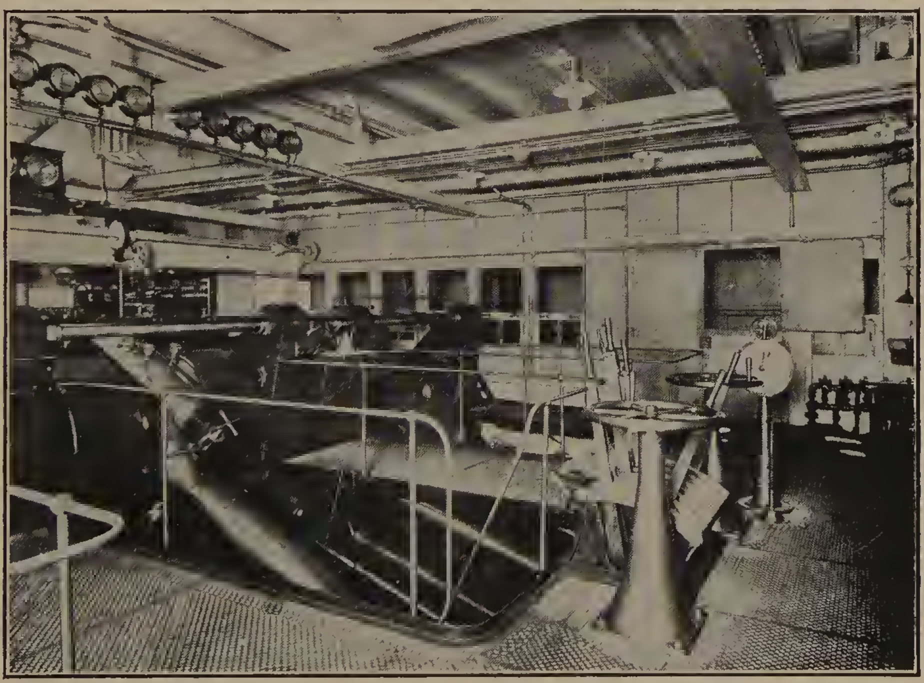
Comparison Between Giant Lake and Ocean Passenger and Mail Ship

	Lake Ship	*Ocean-going Ship*
Length b.p.	484.5 ft.	480 ft.
Beam molded	58.1 ft.	58.1 ft.
Depth molded	24.0 ft.	36.5 ft.
Total No. of full decks	5	5
No. of full decks above strength deck	4	2[1]
No. of full decks below strength deck	nil	2
No. of pass	1500	244 max.
No. of crew	85	132
Power	11,000 i.hp.	8500 i.hp.

The arrangement of passenger accommodation, freight space and machinery spaces follows, in general, that adopted in Sound ships. The main strength deck, known as the main deck, has one partial deck below — forward and aft of the machinery — and four full passenger decks above. The aft end of the main deck contains the entrance lobby with stairs to the atrium, as it is called, above, and is shut off from the rest of the deck by the galley. Forward of the galley practically the entire main deck space is devoted to package freight and automobile space, being served by side doors and obstructed only by boiler upstakes. Crew accommodation is forward on the lower deck, while aft on the lower deck are the stewards' quarters. Promenade, gallery, and upper decks, and in some ships a light sun deck are devoted exclusively to passenger accommodations, the most striking feature of which is the large well extending fore and aft a distance of 70 ft. or so, with a width of about 20 ft. piercing the two upper decks

[1] Top deck is long bridge.

and surmounted on the upper side of the topmost deck by a ceiling painting usually presenting the appearance of figures looking down into the well. Full benefit of the painting and of the height of the gallery can best be appreciated from the lounging space on the upper deck. The well spaces on these giant sidewheelers are among the most spectacular pieces of architecture to be found on any type ship afloat. They are dignified and artistic in *motif* without the glaring garishness so often found on pure excursion ships. Cabins are arranged towards the sides of the decks, the double rows previously mentioned in connection with sound ships being worked in these ships also.



Sidewheel propulsion is a necessity for big sidewheelers like Ss. Seeandbee. This shows the main engine starting platform.

Sidewheel propulsion is practically a necessity for a ship type of this nature with so many superstructure decks. It gives ample deck space, because the sponson lines are faired into the ship's deck line forward and aft, without increasing the breadth on waterline. The Sound ship does this by using the flared midship section only and the screw for propulsion but her proportions of

length on waterline to beam on waterline are considerably smaller than those of the Great Lakes ship. Furthermore the Sound

Luxurious interior decoration is a feature of the cabin-surrounded galleries of the monster passenger carrier, Ss. Seeandbee.

ship has practically no length of parallel middle body in her hull — nor in her deck superstructure — whereas a 400 ft. Great Lakes

ship may have as much as 15 per cent to 25 per cent parallel middle body in her hull. In a long, comparatively narrow, fine-at-the-ends, type of hull structure the paddle wheel gives transverse stability while the inclined machinery spread athwartships keeps the center of gravity low, which further increases stability.[1]

Side loading of autos is a feature of Seeandbee and other giant Lake sidewheelers.

Most of the strength and weight of the hull, in fact, is concentrated in the portion below the main deck. Turbine machinery is the only other type of machinery which could conceivably keep the center of gravity low but with this other hull modifications would inevitably require to be made. Besides, in the limited space available and with the delicacy of balance required in a hull of 480 ft. x 58 ft. x 24 ft. molded dimensions, it is not wise to have shaft tunnels leading to screws and it is not possible to arrange machinery aft. Diesel-electric propulsion with motors driving either paddle wheels or screws aft would give an economical layout as regards operating expenses owing to the great economy of the Diesel generator but might, in inexperienced hands, lead to costly

[1] An average metacentric height is 5 ft.

repair bills. It seems unlikely that any change will be made in the present system of propulsion in future designs for some years. Especially is this so in view of the comparatively limited number of these ships built.

Navigational equipment is of a high order and on some of the later vessels considerable attention has been given to sounding devices of automatic continuous recording types which obviate danger due to grounding in shoal waters and act as check upon the course the ship is following.

An ordinary transverse system of framing is used in the hull structure, one 484 ft. ship having 5 in. x 3 in. bulb angle frames. Special fore and aft girders are arranged to take care of the longitudinal strength of the structure. The double bottom tanks are used for the storage of boiler feed water and water ballast. Large trimming tanks are also provided for use in emergency.

Protection against fire is an item of some importance on ships of this type which have so much wooden structure in their upper-works. Most of the ships have automatic fire alarms, safety fire bulkheads and a complete sprinkler system.

The ships generally are well equipped. Some leading particulars of *Seeandbee*, one of the largest side wheelers operating on the Lakes, are worth studying in conjunction with the foregoing details. Her principal dimensions have already been listed in comparison with those of an ocean-going ship. The data below is additional.

Lake Sidewheeler Details

Tanks

Purpose	*Capacity*	*Number*	*Position*
Trimming	90 tons total	2	Abaft amidships
Water ballast	1714 tons total	9	2 in peaks: rest in double bottom

Engines

3-cylinder compound, inclined, 11.00 i.hp., takes steam from nine cylindrical boilers — 6 single ended, 3 double ended.

Following is a schedule showing the distance between some of the principal terminal points on the Lakes connected by the large side wheelers, also the time taken and the average speed maintained over that distance.

All these runs are overnight and for this reason they catch a certain amount of business traffic. Where there is traffic of this nature, combined with freight transportation it is a paying proposition to keep the route open as long as possible. From Cleveland to Detroit is a good example of this. The journey by railroad takes about 5 hrs. 50 min. overnight as against the 7 hrs. 15 min. water route but the latter gets the travelers into Detroit from Cleveland at a later more reasonable hour — 6.45 A.M. in contrast with 5 A.M. There is thus a very definite competition between the railroad and the water route and therefore the water route runs within the limits of navigation — April to December.

GIANT SIDEWHEELER SCHEDULES

Route	*Time in operation*[1]	*No. of Ships*	*Distance*	*Time*[2]	*Average Speed*
Buffalo–Cleveland	May 1–Nov.	14 3	180 m.	10 hrs.	18 m.p.h.
Buffalo–Detroit	May 15–Nov.	1 2	285 m.	15 hrs.	19 m.p.h.
Cleveland–Detroit	April 1–Dec.	1 2	105 m.	$7\frac{1}{2}$ hrs.	14.4 m.p.h.

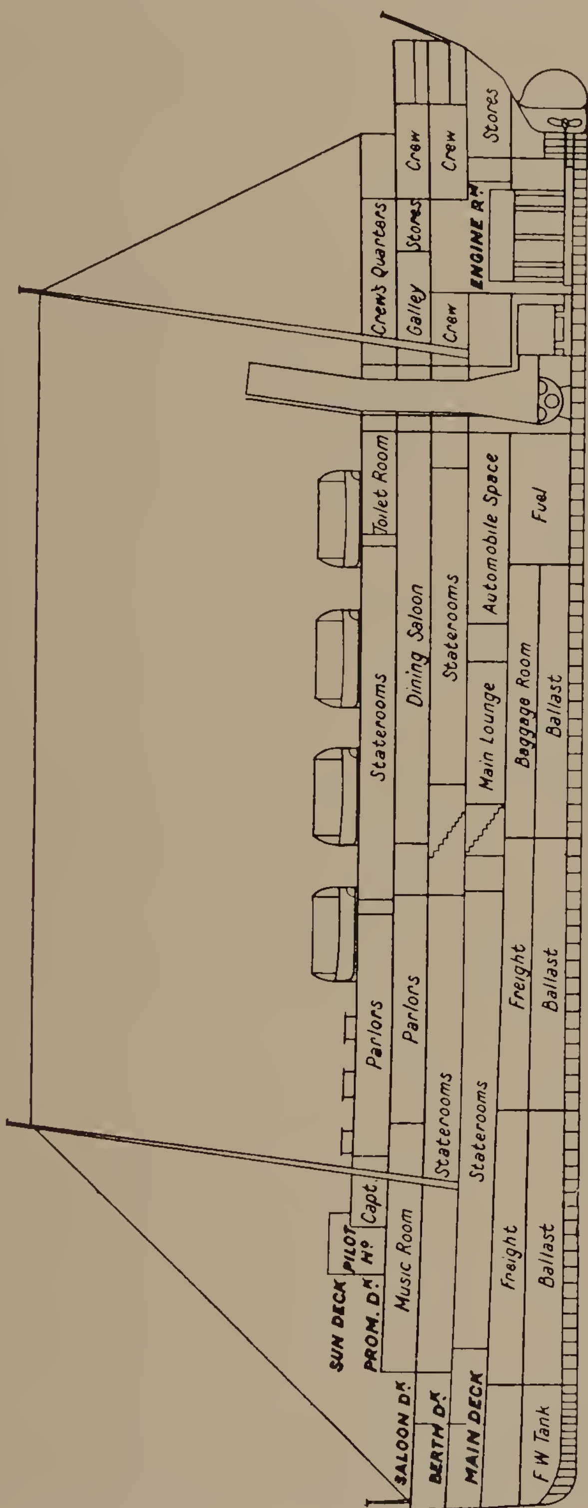
Freighter Type of Passenger Cruising Ship

The Great Lakes Freighter is a long structure with considerable length of parallel middle body having an absolutely clear cargo hold from the fore peak bulkhead to the forward machinery space bulkhead, the machinery being arranged aft and the pilot house right up forward with quarters for the navigating officers underneath. Average dimensions for freighters of this type which do not navigate east of Buffalo and the Welland Canal are 350 feet to 400 feet in length b.p. by 45 feet to 55 feet beam molded and 28 ft. to 35 ft. depth molded. Of this length about 75 per cent, and of the depth molded 100 per cent is occupied by cargo space. The freighter cruising ship is the freighter with three complete decks arranged in the freight space and two superstructure decks built above. This is the genesis of the design which proves remarkably effective in service. Detail arrangements vary with different ships but in the main the foregoing description applies while the following is the outlay of a particular ship. Side load-

[1] i.e. Time during which navigation in open or traffic warrants.

[2] Best time in each case.

The "Freighter type" of Lake passenger carrier, used for busy summer tourist work. Machinery is arranged aft.



Inboard profile of "Freighter type" Lake passenger carrier shows disposition of passenger decks, saloons, and freight spaces.

ing arrangements are used in the manner adopted in coastwise ships. In these cruising ships a large space on the main deck is devoted exclusively to the carriage of automobiles: forward of this is the entrance lounge with side entrances, and forward of this again cabins on either side of a central gangway. The deck above, known as the berth deck, is devoted exclusively to passenger accommodations forward of the machinery space while the engineer officers are aft of this on the same deck. The saloon

Side-loading on a big Canadian Pacific tourist ship at a Lake port.

deck, which actually is the strength deck of the hull contains a music room, with a rounded fore end, forward. Eight *suites de luxe* are abaft this. Then there is a lounge, followed by a large dining saloon, which though practically amidships is absolutely clear of uptakes from the boiler or engine casings, due to the fact that the machinery is aft. The galley is arranged aft of the dining saloon. The promenade deck is the first superstructure deck and is devoted to a house with promenade space all around. The second superstructure deck — above this — is a sun deck containing life boats and devoted to promenade space. The decks

throughout are clear because the machinery is aft, and this arrangement permits of compact and unbroken passenger accommodation. A lower deck runs fore and aft forward of the fuel cross bunker and has a baggage room and package freight space. Below the lower deck or rather between it and the tank top large water ballast tanks rendered necessary to keep the vessel at reasonable trim because of the heavy machinery weight aft.

These Great Lakes cruising ships with machinery aft are directly comparable with the Matson Liners operating between San Francisco and Honolulu. They make an interesting contrast with the Giant Sidewheelers.

It must be noted that a modification has been made in some of the later cruising ships in the Lakes by putting the machinery amidships and arranging the accommodation around the casings, which are remarkably compact and occupy very little space. These represent a later development of the original freighter idea and the ships themselves are virtually coastwise ships except that the hulls are built on bluff Great Lakes lines with the pilot house well forward on the forecastle.

Following is a table giving principal characteristics of typical Great Lakes cruising ships. These should be contrasted with the large sidewheeler mentioned previously and also with the Matson liner included in that table. This vessel has machinery in the stern and clear decks the same as the Lake cruising ship.

Characteristics of Great Lakes Cruising Ships

Length b.p.	346 ft.	336 ft.	259 ft.
Beam molded	45 ft.	43 ft. 8 in.	47 ft. 1 in.
Depth molded	28 ft.	26 ft. 6 in.	18 ft. 3 in.
No. of decks below main deck	2	1	2
No. of superstructure decks	2	2	2
No. of passengers	450	300	450
Power	3000 i.hp.	2500 i.hp.	2000 i.hp.
Machinery	aft	aft	amidships
Gross tonnage	4333 tons	3880 tons	2317 tons

Cruise Ships Work West of Buffalo

There are minor differences in the routes followed by these cruising ships but generally speaking the tendency is for them to

work westward from Buffalo or, in the case of Canadian owned ships, from Port MacNicoll. Ports east of Buffalo are ruled out of account because the ships are all too big to negotiate the Welland Canal locks.

Chicago, Duluth, and Georgian Bay Transit Co. operates between Buffalo and Chicago from the beginning of July to the beginning of September by way of Detroit, Mackinac Island, completing the cruise by returning by way of Mackinac Island, Parry Sound, Detroit, and Cleveland. The complete cruise — Buffalo back to Buffalo — occupies eight days.

Canadian Pacific Railway ships cruise between Port MacNicoll and Port Arthur via Sault Ste. Marie from June until the end of September.

Great Lakes Transit Corporation maintains a regular service between Buffalo and Duluth by way of Cleveland, Detroit, Mackinac Island, Sault Ste. Marie, and Houghton commencing in June and terminating in September, and in connection with this it is indicative of the scheduled times which the Lakes cruising ships maintain to reproduce the following detailed logs of one Westbound trip.

Typical Log of a Lakes Cruising Ship

Westbound			*Miles from Buffalo*
1st Day	Time		
Leave Buffalo (Passenger Terminal) E.T.	9.15 AM		
Leave Buffalo (Automobile Dock)	9.45 AM		
Breakwall, Abreast	10.00 AM		
Point Abino, Abreast	10.45 AM		
Ashtabula, Abreast	6.00 PM		
Fairport, Abreast	8.00 PM		
Cleveland Breakwater, Abreast	10.00 PM	stop	180
Leave Cleveland	11.00 PM		
2nd Day			
South East Shoal, Abreast	2.30 AM		
Bar Point, Abreast	5.00 AM		
Detroit, Arrive	7.00 AM	stop	285
Detroit, Leave	11.00 AM		
Arrive Ship Canal, Abreast C.T.	12.00 Noon		
Fort Gratiot, Abreast	3.45 PM		
Lake Huron Light Ship, Abreast	4.00 PM		

Typical Log of a Lakes Cruising Ship (*Cont.*)

Harbor Beach, Abreast	7.50 PM		
Point Barques, Abreast	8.50 PM		
3rd Day			
Spectacle Reef, Abreast	6.45 AM	stop	590
Mackinac Island, Arrive	8.15 AM		
Mackinac Island, Leave	10.45 AM		
Martins Reef, Abreast	12.30 PM		
Detour, Abreast	1.15 PM		
Up St. Marys River to Sault Ste. Marie	5.30 PM		
Leave Sault Ste. Marie	7.00 PM		
Arrive Locks Sault Ste. Marie	7.15 PM		
Lockage, 30 Minutes			
Point Iroquois, Abreast	9.10 PM		
Parisiene Island, Abreast	10.00 PM		
White Fish Point, Abreast	11.00 PM		
4th Day			
Huron Island, Abreast	9.00 AM		
Portage Entry, Abreast	10.30 AM		
Houghton, Arrive	12.00 Noon	stop	935
Houghton, Leave	5.00 PM		
5th Day			
Devils Island, Abreast	1.00 AM		
Arrive Duluth	7.30 AM	stop	1115

In addition to the regular cruises maintained by the freighter type of cruising ship described in the foregoing it is customary for one or more of the giant sidewheelers to make what is described as an annual cruise. *Seeandbee*, giant of the Cleveland–Buffalo service, makes a September cruise from Buffalo to Chicago and back, via Cleveland and Sault Ste. Marie outward and via Mackinac Island and Cleveland homeward, the round trip occupying about eight days. Although vessels of this type are not economical ships for cruising purposes since the whole purpose of their design is for short high speed night runs, their cruises are a tremendous popular success while their splendid public rooms and airy cabins make them perfectly comfortable for protracted periods at "sea." The tourist business on the Lakes, though perhaps insignificant compared with the bulk cargo trade, is an important and ever increasing one, and the pure passenger business

can, during the months in which navigation is open compete very successfully with the railroads. Each branch — passenger and tourist — is taken care of by a ship type peculiar to the waters in which it operates and particularly efficient for the work. The giant sidewheeler is something apart in naval construction; the cruising ship is a direct application of the unaesthetic bulk freighter to a special need.

The type has many features which can be incorporated in our ocean-going and coastwise ships of moderate size with advantage. Difficulties of trim in passenger ships with machinery aft where the loading seldom varies are not as apparent as in freighters, and the clear deck spaces resulting are a great benefit.

Three Big Groups of Dredges

Make Waterways Safe for Navigation by American Ship Types

DREDGES strictly cannot be claimed as American ship types, since they form part of the equipment of any and every port and harbor. American dredges, however, are among the most efficient — the largest of such craft to be found. They perform exacting work in keeping harbor entrances clear, in maintaining standard depths of water in ship channels designed to take the world's largest ships, in deepening the large rivers, in cleaning dock entrances, in making fills and in sand removal and transportation. The last named operation is a strictly commercial one in which the object is not primarily the removal of sand but the obtaining of sand for a definite purpose. For these purposes there are three distinct types employed — the sea-going hydraulic hopper dredge, the pipeline dredge, and the dipper dredge. The first two types belong to the suction group of dredging machines and the third comes under the head of the digging group. Dipper dredges originated in this country and are used generally only in this country. Abroad, the ladder or bucket dredge is generally used in place of the dipper dredge, while outside U. S. the use of the pipeline dredge is largely confined to the Dutch inland waterways. The sea-going hydraulic hopper dredge is used in the harbors on the coasts of Great Britain and the Northern German River entrances. Holland and Germany have done much pioneer work in developing dredging machines suited to the solution of their own particular problems which are concerned entirely with the removal of sand from river entrances, but it has remained for America to develop the numerous machines which provide navigational facilities for the legions of ships which yearly use her

harbors, and to realize the value of the Diesel engine for this class of work practically to the exclusion of steam. In this work the U. S. Army Engines have been very prominent.

If we consider the matter analytically, we find a dredge is a very particular example of a constructional "mechanical mixture." She comprises a dredging machine plus the prime mover for driving the machine, plus the means for removing the dredged material, either to discharge it via pipes or to contain it, plus a hull on which or in which the other ingredients can be arranged, plus — in some cases — machinery to propel the hull and its contents. Then there are several ways in which the "ingredients" may be arranged shown best in the following table of comparative analysis:

The American Dredge

- Sucking
  - Hydraulic Sea-going Hopper
    - Side Ladder
    - Center Well
    - Trailing Ladder
  - Pipe Line
    - Plain Suction
    - Suction Cutter
- Digging
  - Dipper

The sea-going hopper dredge is essentially intended for work in exposed harbors and in channels approaching harbors. She is self-contained, sufficiently large and weatherworthy to withstand a certain amount of knocking about and these characteristics enable her to keep on station in all but the severest of weather. She has her own hopper space and this does away with the necessity for maintaining a scow service to and from the vessel with the material removed. Scow service moreover can only be maintained in the finest of weather. The pipeline dredge (known outside the U. S. as a suction reclamation dredger) is a different proposition entirely. She is used very often in shallow water, and in some cases may be required to cut her own flotation. Ship channels in sheltered water — such as the Delaware River as far as Philadelphia — are maintained by pipeline dredges which

may discharge either into scows alongside, or, as is more generally the case into some fill. One of the best examples of work done by that class of dredge is to be found in Galveston Bay where a complete island facing the back or "shoreward" side of Galvez Island has been built up from material dredged from the Galveston ship channel and especially from material removed from around the piers in the harbor.

The centrifugal pump coupled up to some prime mover is the

The sea-going hopper dredge is large, self-contained and weather worthy. This is a big ship of side drag type.

instrument employed in both sea-going hydraulic dredges and in pipe line dredges and the material dredged is removed literally by suction, assisted in some cases by cutting action.

The dipper dredge is in effect a mechanical shovel mounted on a floating hull. It is very useful for removing mud from around the entrance of graving docks and wet docks but is probably at its best when working on heavy clay — too dense for a sucker to work on — or rocky bottom. In the latter case it is usually a follow on to a rock drill.

The Pipe Line Dredge

The pipe line dredge consists essentially of an oblong shallow hull — an idea of the dimensional proportions will be obtained

from the table below — having a centrifugal pump whose main pipe line is attached to a dredging ladder or arm at the suction end and runs the length of the hull discharging over the stern into scows or ashore via a pipeline. This pump is coupled direct to some prime mover, either a Diesel engine or an electric motor, the steam engine being now practically obsolete for dredge work. Pump, pump prime mover, and their respective auxiliary machinery occupy practically the whole of the hull.

Pipe Line Dredge Characteristics

Length o.a.	238 ft. $6\frac{3}{4}$ in.	236 ft.	170 ft. $7\frac{1}{2}$ in.
Length molded	175 ft.	—	130 ft.
Beam molded	50 ft.	50 ft.	33 ft.
Depth molded	8 ft.	12 ft. 9 in.	8 ft. 8 in.
Draft (load)	4 ft. 7 in.	7 ft. 8 in.	5 ft.
Pipe line dia.	24 in.	30 in.	26 in.
Pump engine	1200 i.hp.	2700 b.hp.	500 b.hp.

The tops of the main engine project well above the hull main deck. The main deck is a continuous structure except in way of the main and auxiliary engine cylinder tops and the top of the dredge pump so that viewed from the main deck, the principal machinery has the appearance of being situated in a well. The main deck has a complete house about 10 ft. in height arranged on it so as to leave a narrow walkway on either side of the ship and at the aft end, the aft end walkway being slightly wider in order to allow for the gear attached to the two large vertical mooring spuds. The walkway forward is recessed in conformity with the rest of the hull in order to allow for the lowering of the dredging arm. Forward the hull narrows and, viewed in plan has the appearance of a truncated cone. This part contains also the supports for the tackle which raises or lowers the dredging arm. These details are made clear by referring to the plans and illustration.

The house on the main deck contains at its forward end a powerful windlass with barrels for controlling the lift and swing of the dredge arm or ladder, for handling heavy mooring cables and a warping barrel at each outer end for mooring the vessel and for maneuvering her alongside quays. The main deck house

Typical big pipeline dredge with cutter attachment over dredge arm.

has also workshop machinery and odd auxiliary machinery not housed in the main hull. In certain cases it contains also a motor driven booster pump, used where the vessel is making extensive fills for assisting the dredged material to its destination. The material is pumped along lengths of piping arranged on floats. At the aft end of the main deck house is the gear for handling the morning spuds and for running out cables as necessary.

Running practically the full length and width — except for narrow walkways — of the main deck house is a further house containing accommodations for the dredge's crew, while above this again at the forward end is a small control house containing controls for the main pump engines, if electric drive is used, or telegraphs if a reciprocating prime mover is employed, controls for the dredging arm windlass, indicators showing pressure, vacuum, etc., on the main pump.

Constructional details are much the same in all dredges of this type and the following description of the hull of a 236 ft., 2480 ton displacement dredge may be taken as representative.

On each side of the hull, located 7 ft. inboard from the shell plating, is a longitudinal watertight bulkhead, extending from the forward athwartship bulkhead to the after athwartship bulkhead, some 188 ft. in length. This strengthens the hull and particularly strengthens the bottom in case of grounding. The space between this bulkhead and the side of the hull is divided by athwartship partitions into six watertight compartments in each side of the ship, used for the storage of fuel oil, Diesel oil, lubricating oil and water.

There are four transverse bulkheads dividing the hull into six compartments. The forward bulkhead is located at the after end of the ladder well, and is the after bulkhead of a compartment on each side of the well. The second bulkhead is 48 ft. aft of the first and is placed between the dredging pump and the pump motor. The dredge has electric drive. The third is 72 ft. back of the second and is placed between two pairs of generators. The fourth bulkhead is 60 ft. farther aft, giving a stern compartment 24 ft. long.

These bulkheads strengthen the dredge through being placed between the different main machinery units and thoroughly tying the machinery keelsons to the longitudinal bulkheads and the side of the hull. In addition there is a heavy frame 4 ft. 2 in. deep, tied to each panel point of the truss, extending to the longitudinal bulkheads and the side of the hull, with additional deep frames 6 ft. apart tied to the longitudinal bulkheads.

One set of engines and generators is in one compartment, a second set in another, while the main dredging pump is in a third. Should the bottom of the dredge be injured, causing the filling of any one of the compartments, the damage would be local and affect the electrical equipment in that compartment only. Similarly, should a hull pipe or the dredging pump be ruptured from any cause, the damage would be limited to the compartment where the damage occurred.

There are heavy steel trusses extending the full length of the hull, the forward ends being extended to form the A-frame for the ladder hoist and the spud masts aft being tied into, and forming a part of, the trusses. These trusses are calculated to support the weight of the dredge in case of grounding on two ends. Each of the side trusses is located one-half the distance from the centerline of the hull of the side plating. There is ample space between the trusses and the longitudinal bulkheads for passageways and auxiliary pumps on the port side and for the hull pipe and passageway on the starboard side.

The panel points are spaced 36 ft. apart and the angle of the diagonal members is approximately 45 deg. Forward of the deck house the top members of the trusses converge, meeting the forward member of the A-frame 32 ft. forward of the bow. At this location a structural steel frame is formed, carrying five sheaves for the ladder hoist tackle, the lower member of which consists of a quadruple sheave block chained to the digging ladder near the outer end. The after end of the truss is built into the spud-well frames and spud-mast frames. The spud masts are sufficient in height to accommodate the 80-ft. spuds and so designed that they may be used to unship or ship a spud in case of breakage.

Each spud is 35 in. diameter and 80 ft. long, constructed of $\frac{3}{4}$-inch steel plates rolled into a cylindrical tube. There is a hollow cast-steel conical point at the bottom for settling into the bed of the river. There are 14 flanged diaphragm plates riveted to the shell, spaced about 5 ft. apart throughout the length of the spud, which keep the spud from buckling under a beam strain. Constructed in this manner, these steel spuds have double the strength of timber spuds of the same diameter, and are easily repaired or rebuilt in case of injury.

The spud wells are placed at the stern and constructed with heavy cast-steel hinged keepers to enable the spuds to be removed should they become bent. The dredge crew with the equipment aboard can readily replace a broken spud, etc. On dredges, designed with spuds in wells through the hull, when a spud is broken it often necessitates laying up the dredge for several days and towing it to the most available sheer legs to install the new spud. The pipe line dredge is operated in one of two ways: either the main dredge pump is coupled direct to a single acting non-reversible Diesel, or Diesel driven generators supply current to an electric motor which actuates the dredge pump. In either case the principal auxiliary machinery on the ship is electrically driven and Diesel generators are supplied for the purpose. The auxiliary machinery comprises the pumps necessary for the operation of the main Diesel, motors actuating the dredge arm hoisting winch, the booster pumps, when fitted, the cutter gear and the spuds, as well as the mooring capstans.

The Hydraulic Sea-Going Hopper Dredge

Considered in one way, the pipeline dredge is as much a machine as a ship, the hull being merely a floating home for the machinery. Adequate strength to take the different machinery weights coupled with sufficient beam for stability under various conditions of operation must always be provided, but otherwise, as far as the hull is concerned, the only limiting factor is draft. This is not such a serious problem as it appears because the ma-

chinery is not necessarily restricted to the confines of the hull proper. The sea-going hopper dredge is, however, from the beginning a different proposition. Within the limits of a seaworthy, ship-shape hull, a designer is required to arrange the dredge pump and its auxiliary and operating machinery, propelling machinery for the ship, hopper-space for the dredged material, machinery for operating the hopper doors, provision for and winches for raising and lowering the dredge arm or arms. Adequate longitudinal strength must be provided for the two extreme conditions of loading; i.e., with hoppers full and hoppers empty, while transverse

U. S. Army dredges of the A. Mackenzie class are of Diesel-electric type.

stability must be sufficient to ensure that the deck edge is above the water, with the hopper spaces on one side of the centerline full and the other empty — a condition which sometimes momentarily arises under certain conditions of operation. Full navigating equipment such as is normally found on a sea-going ship must be fitted, while the crew necessarily is larger than that of a pipeline dredge — in fact, it is virtually doubled — for this reason.

Above are the principal ingredients — there are various ways of mixing them. The propelling prime movers can be arranged aft to drive the dredge pumps as well as the screws. It should be

explained here that this type of dredge invariably is twin screw because at the slow speeds at which dredging is carried out a single rudder, depending for its operation upon the flow of water particles past it from the screw, is practically useless.

With prime movers and pumps aft, the hopper space is continuous from the forward machinery space bulkhead to the fore peak bulkhead. This arrangement is chiefly followed in smaller ships and is more used in Europe than in American waters.

Another arrangement splits up the machinery into its two respective groups — propelling units aft and pump units forward with hopper space between. This layout has been adopted by the Army Engineers in the fine vessels of the *A. MacKenzie* class. This has many advantages, chief among which are the even distributions of weight. A third layout which does not appear to have many recommendations, places the prime movers for actuating the screws and dredge pumps respectively, abaft the hopper space while the source of power — in this case a battery of water tube boilers — is arranged forward of the hoppers. A length of heavily lagged steam piping is thus required to be carried along the ship for the hopper space distance from boilers to engines. In addition to this structural disadvantage, there is liable to be an appreciable drop in steam pressure between the boiler and the prime movers.

The above remarks have taken care of the arrangement of hoppers. There is a similar choice of arrangement for the dredge arms. If two arms are arranged to pivot in a vertical arc about their points of entry to the hull on either side of the hull, the dredge is known as a side drag type. This is in contrast to the center well type in which the dredge arm pivots, again in a vertical arc, about a fulcrum (the fulcrum being the point at which the arm is attached to the dredge pump suction pipe) either in the center of the hopper space or at the aft end of the hull. In the latter case the dredge is split vertically into two ships — each with its propeller and rudder — at the aft end. The side drag type can operate on one side only or on both sides and for this reason is somewhat more flexible in operation but if the drag pipes enter

the hull at load waterline level they are apt to cause a certain amount of resistance to propulsion, and for this reason in certain more modern vessels, the pump ends of the two drag pipes are arranged to be raised or lowered in vertical slots on the ship's side. Thus, when dredging, the ship has both pipes lowered and the pump ends of the drag pipes are in direct communication with the dredge pump suctions. When traveling loaded to the dumping ground both suction end and pump end are lifted entirely clear of the water, by means of derricks on the deck above.

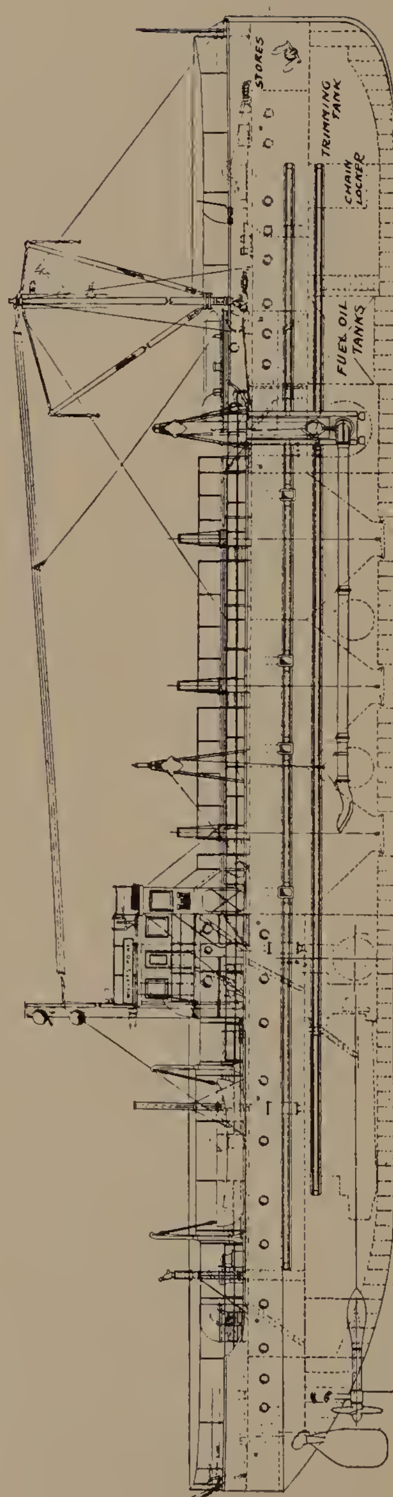
Dredges having a drag line on either side of the hull sometimes have one pump with a larger capacity than the other, the large pump having a shore connection which enables the vessels to be used as a pipeline dredge if necessary. Following is a table giving particulars of pump capacities of recent modern hydraulic hopper dredges.

Hopper Dredge Pump Capacities

Hopper Cap.	*No. of Hoppers*	*No. of Pumps*	*Dia. of Pipes*	*Power of pumps*
1250 cu. yds.	4	1	26 in.	610 b.hp.
3000 cu. yds.	8	2		Port 400 b.hp. Std 2000 b.hp.
3000 tons.	2	2	18 in.	4000 b.hp.

Construction, except in the way of hopper spaces, is of conventional transverse type with flat plate keel and floors and side keelsons. In way of the hopper spaces, however, a somewhat different construction is necessary. If the dredge arm is in a well amidships this well divides the hopper space longitudinally and compensating longitudinal strength must be provided. In any case, of course, the hopper space is divided also by transverse bulkheads, and although a portion of the ship amidships is actually removed, the side and end bulkheads of this well form a species of hollow box girder while heavy box girders on the deck overhead taking the gate valve lowering gear assist materially in maintaining adequate strength. Longitudinal bulkheads form the side to the dredge arm well. In cases where the suction pipe is

located in the stern, the hopper space has a single longitudinal bulkhead and the usual transverse divisions. Longitudinal bulkheads divide the stern in the way of the drag arm. The most intact type of hull structure actually is secured in the side drag type of dredge because there is no well needed for the dredge arm. The hopper spaces follow very closely the arrangement adopted in self-unloading bulk freighters discussed in a previous chapter — i.e., they are shaped like truncated pyramids with steel slopes fore and aft and athwartships so that all the solid material which is to be dumped at sea tends to flow towards the apex where the gate valves or hopper doors are situated. These are opened and closed from the deck either by means of chains and winches or by hydraulic rams. The following arrangement of structional members, with their scantlings, for an hydraulic sea-going side drag hopper dredge of light draft may be taken as generally representative. The vessel illustrated herewith which was completed in 1926 for the U. S. Army Engineers has a length b.p. of 193 ft., a beam molded of 41 ft., a depth molded of 19 ft. 6 in. and a mean draft light with hoppers dry of about 7 ft. 11 in.



Shallow draft hopper dredge with side drags operating in vertical guides designed to pass through N. Y. State Barge Canal.

The flat plate keel is 42 in. wide and $\frac{5}{8}$ in. thick throughout the hopper space, with $\frac{1}{2}$ in. material forward and aft of the hopper space for about three-fifths of the length and reduced to $\frac{7}{16}$ in. at the ends. The vertical keel is continuous from frame 5 to frame 86, and of $\frac{3}{8}$ in. plating throughout. The top of the keel is 27 in. above the base line from frame 15 to frame 86, except in way of the oil tanks where it is increased to 36 in. Aft of frame 15 the depth of this keel is gradually increased to 8 ft. 1 in. above the base line of frame 5.

Transverse frames are spaced 24 in. heel-to-heel throughout. Except in the hopper space and in the bow and stern framing, the frame bars are $6\frac{1}{2}$ in. x 3 in. x 13.6 lb. bulb angles, cut to 3 in. x 3 in. section in way of the lower edge of the floor plates. The frames extend from the centerline of the ship to the main deck, except in way of the water-tight lower deck where the frame bars are cut and bracketed.

Plating is $\frac{7}{16}$ in. for three-fifths of the length amidships and reduced to $\frac{3}{8}$ in. at the ends. The boss plate, however, is $\frac{1}{2}$ in., and for the bilge-strake, the garboard strake and the strake below the sheer strake $\frac{1}{2}$ in. plating is used, reduced at the ends. The sheer strake is $\frac{9}{16}$ in. in way of the hoppers, reduced to $\frac{3}{8}$ in. at the after end and $\frac{1}{2}$ in. forward.

Floors are worked transversely and spaced 24 in. heel-to-heel. They are 27 in. deep with the top parallel to the base line from frame 15 to frame 86, except in way of the oil tanks, where the depth of floors is increased to 36 in., and aft of frame 20 where they are 27 in. deep to side keelson No. 1 whence they are sloped up to the ship side. Aft from frame 6 to 14 inclusive, the heights of the floors are increased to suit the height of the centerline vertical keel and the top of the floor run parallel with the base line. The floors are $\frac{7}{16}$ in. plating for three-fifths of the length and under the machinery, reduced to $\frac{3}{8}$ in. at the ends, except that floors 30 to 34 and 66 to 70 inclusive are $\frac{1}{2}$ in. plating.

There are two keelsons. Side keelson No. 1 is fitted forward and aft of the hopper space and between frames 35 and 9 and located to suit the outboard engine girder, of which it forms a

part. It consists of two continuous 4 in. x 3 in. x $\frac{7}{16}$ in. angles running on top of the floors, and $\frac{3}{8}$ in. intercostal plates placed between the continuous face angles. Side keelson No. 2 is also fitted forward and aft of the hopper space, 13 ft. 6 in. from the centerline between frames 65 and 71, 11 ft. from the centerline between frames 71 and 78, 12 ft. 5 in. from the centerline from frame 35 aft to frame 21 and then, 13 ft. 9 in. from centerline.

There are four water-tight bulkheads extending to the main deck and a similar number of water-tight bulkheads extending between the keel and the lower deck.

There are 5 hoppers, over which walkways are fitted on port and starboard sides and athwartships. Under the hoppers a walkway is constructed from the engine to the pump room on port and starboard.

Hopper Dredge Operation

When the dredge reaches the bar to be dredged,[1] the pump is started. The drags are lowered to the bottom with the pumps turning, and the ship travels over the bar at as slow a speed as is consistent with maintaining steerage way with the aid of the twin screws. Proper speeds range from $\frac{1}{2}$ to 2 knots over the bottom, which must often be increased in a strong current. Material is loosened from the bottom by the weight and motion of the drag, and by the suction, assisted where the bottom is clayey or unduly hard by plows or scrapers attached to the drag, or, in some cases, by water jets, and is then drawn up by suction into the pumps, from which it is discharged through pipes or other leaders into the bins. The bins are provided with overflows slightly below the top of the coaming to carry off the surplus water.

The dredge thus cuts a furrow or furrows (one for each drag) the length of her cut when, if not already loaded, she turns and goes back along the cut. These furrows are very nearly the width of the drag (from 5 to 20 ft.), and in depth vary from scant 1 in. to about 6 in., depending upon the nature of the bottom. Thus the

[1] Refer here to a paper by Major W. D. Styer, U. S. Army Engineers, entitled "Hydraulic Sea-going Hopper Dredges" read before the Society of Naval Architects and Marine Engineers, 1924.

dredge has to make many trips over the shoal if the excavation is to be of considerable depth.

A dragtender stationed in full view of each suction pipe controls the drag by raising or lowering it so as to maintain the proper pressure on the bottom for efficient dredging. Care must be taken that the ship does not drift over against the suction pipes. Another duty of the dragtender is to raise the drag from the bottom when passing over an area already of the required depth, in order to avoid excessive overdepth.

When the bins are full or sufficiently loaded, the drags are raised out of the water, the contents of the bins measured, and the ship proceeds at her full speed to the place for deposit, where the gates in the bottom of the hoppers are opened and the material is discharged. In dumping, a moderate speed is maintained in order to scatter the material, except where the dumping ground is a restricted area when the ship comes to a full stop.

A Converted Freighter

One of the most interesting dredges now in service is the Diesel-electric *Sandmaster*, converted from a three island Lake type Shipping Board freighter to a side drag dredge for sucking sand from the bottom of Lake Michigan and transporting it to Chicago to be used there in making fills on the lake front. Diesel-electric propelling equipment was arranged in the old engine room, electric propelling motors fixed aft and electric dredge pumps fitted. The holds forward and aft of the machinery space were converted into hopper spaces, or rather sand holds, because the sand is not discharged in the usual method by being dropped out through the ship's bottom, but pumped over the side. The vessel has a sand capacity of 3000 tons. Two drag pipes — one on either side — are coupled up to two 400 hp. motor driven pumps. Two propelling motors of 1000 collective s.hp. give the vessel a loaded speed of 9 m.p.h. *Sandmaster* is not a dredge in the ordinary sense of the term but she has been specially adapted to a particular purpose and actually she is a self-unloading and loading sand carrier. She could if necessary be employed on ordinary work and her size does not bar her from passing the Welland Canal.

Light Vessels and Light Tenders

Have Special Characteristics for Particular Conditions of Operation

LIGHT vessels belong to a ship type with a peculiar function. This function is to warn shipping of a proximity to a sandbank, rock or other navigational obstruction. Light vessels are found in all parts of the world, and the only justification for including them in this catalog of domestic ship types is the fact that American light vessels differ in arrangement from similar ships in other countries. They are all self-propelling and in this they differ entirely from British light vessels, or lightships as they are called, though not from German, Scandinavian, French, and Dutch vessels. The reason for making them self-propelling is so that they can take care of themselves in the rough weather and severe storms to which they are exposed. Nantucket Shoals light vessel — the first "landmark" seen by the transatlantic passenger entering the port of New York is anchored in 30 fathoms of water, 41 miles from the nearest land. San Francisco Light vessel is moored 3 miles outside the bar. Diamond Shoal light vessel is situated in 30 fathoms of water 13 miles off Cape Hatteras.

The second point of difference from other light vessels is one of profile. The American ship generally — there are exceptions — has her lighting elements divided into two, and two lamps are arranged, one each at the top of a pole mast. Cones, cages, and other day marks are arranged on the masts above or below the lanterns. The later type lantern is fixed to the top of the mast, which is of steel plate construction; the old style consisted of three lanterns in iron frames which were raised and lowered on the masts. The lanterns are of ordinary Fresnel lens type. European light vessels of modern type concentrate the whole of their light-

ing into one dioptic Fresnel lens, fixed to the top of a short steel mast amidships, the place in which the domestic light vessel has a large stack with a big fog whistle of locomotive type on its forward side. Forward of the foremast is a pilot house. The hull generally is painted red with the name of the particular shoal the vessel is guarding in large white letters on the side. Domestic lightships have generally the two lanterns for safety reasons. One is always in operation and the other standby.

A modern American lightship, stationed off the Delaware with all-Diesel power and a year's fuel supply in her tanks.

Constructionally, light vessels are very strong; the midship section is designed to offer a maximum resistance to rolling. Rolling is apt to happen not only with the ordinary wave motion usually occurring in an exposed position, but also due to the "rebound" of waves off sandbanks in the vicinity. There is usually a bar keel, big rise of floor, and large tumble home, the outline of midship section being somewhat reminiscent of that of an ice-breaker. The sheer is severe, rising rapidly both to the bow and to the stern. The bow is a strong forging and sharply raked,

containing the hawse pipe for the mushroom mooring anchor. Here is also the hawse pipe for a standby anchor.

The stern is of stereotyped single knuckle type and contains the rudder, sternpost of usual construction, and the propelling wheel. Mushroom mooring anchors — in many cases two per ship — are attached to the ship by means of heavy, specially tested, wrought iron cable. Where two anchors are used, they are attached to each other by a single cable and to the main mooring cable by a swivel ring. Diamond Shoal light vessel is moored with 150 fathoms of cable and a 10 ton anchor.

The ships generally have two complete decks and a third part deck forward and aft of the machinery space. Side doors in the hull give access to the second deck and tend to follow the characteristic side loading which, as we have seen, is predominant in so many American ship types.

Besides being of value in an emergency, the propulsive power is useful to enable the ship to proceed to and from her station when due for relief or to relieve. The main prime movers can also be used to furnish auxiliary power for operating fog signals, compressed air whistles, generators for lighting, and radio work. Steam is used in the majority of American vessels at present in service, but Diesel power is being substituted in new ships. Indeed, from the very fact of the occasional demands put upon prime motive power, the Diesel and better still, the Diesel-electric layout would seem to be the light vessel's ideal power plant. Handled intelligently, it is available for instantaneous use and wastes no time, as the steamer does, in firing up boilers. A Diesel driven generator can supply current for motors driving an air compressor of sufficient capacity to operate an air whistle or siren in fog and to supply sufficient air to charge starting up bottles. Heating the ship, on an exposed station, might at first be thought a problem in the Diesel; but it can be overcome by using a small oil-fired boiler.

A modern motor light vessel 152 ft. 10 in. long overall and of 750 tons displacement has a 500 hp. Diesel for propulsion and two 25 kw. Diesel generators for supplying current to motors operating

the fog siren compressor, windlass for the main mooring anchor, weighing 7500 lb., and a winch for hoisting boats. Two 7 kw. kerosene generators operate the signal lights. The vessel has a tank capacity of 48,000 gal. — more than a year's supply. There are two lanterns each located on steel masts 52 ft. above water level.

All modern U. S. light vessels are well equipped with radio outfits and many of them are radio beacons and thus possibly fore-runners of the day when visible and acoustic methods of light and sound signalling will be entirely superseded by wireless methods.

U. S. coastal marking, lightships and lighthouses are among the best in the world.

Light Tenders

An important ship type which conveniently can be classed with the light vessel is the light-tender — a sturdy, heavy lined, bluff bowed ship of under 200 ft. in length, whose chief characteristic is a wide open fore deck, upon which a powerful winch-operated derrick can deposit buoys lifted from their moorings for repair and overhaul, or raise them partially from the water in order to re-charge their cylinders with gas. The tender has to proceed to sea in all weather to make her routine round, and it is quite usual in winter to see a ship returning to her depot with practically a solid mass of ice from her bows to her stack.

The tenders on the coasts and on the Lakes are practically standard in their arrangement, with a short, dumpy forecastle, open fore deck and accommodation abaft this. Columbia River and Puget Sound, however, have shoal draft, sternwheel tenders, similar to the types discussed already in a previous chapter.

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